COMMERCIAL EDUCATION

TEXTILES

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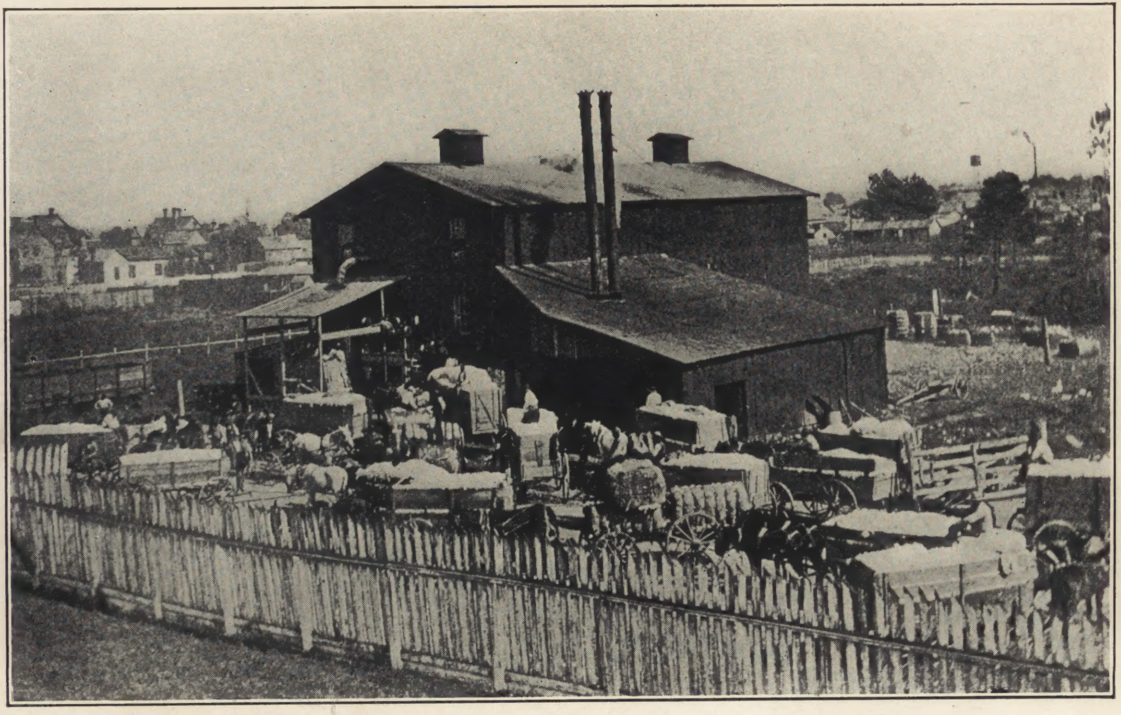

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COMMERCIAL EDUCATION SERIES

TEXTILES

PREPARED IN THE
EXTENSION DIVISION OF
THE UNIVERSITY OF WISCONSIN

BY

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PREFACE

The purpose of this book is to present in concise form the essential facts regarding the ordinary textiles of commerce—the sources of raw material, the methods of manufacture and distribution, the tests to determine quality, the economic aspects of textiles, and the other phases of the subject which are of importance to all who manufacture, sell, or use the products of the textile mills.

It is hoped that the book will prove of equal interest to retail and wholesale salespeople who wish to increase their efficiency by acquiring a thorough knowledge of the goods they sell; to home-makers who, as consumers of textile products, are concerned with the conditions governing their production and distribution; to educational institutions conducting courses of instruction in the textile field; and to the general public seeking definite information regarding a class of commodities that occupies an exceedingly important place in world commerce and which has an intimate relation to the comfort and welfare of all civilized peoples.

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CHAPTER I

THE TEXTILE FIBERS

The demand for clothing.—Food, clothing, fuel, and shelter are four primary needs of the human being. With respect to the importance placed upon clothing there is much difference among the various races. It has been estimated that there are about 1,500,000,000 people living at the present time. Of this number about one third are fully clothed, according to our civilized standards; one half are partly clothed; and the remainder, or about 250,000,000 people, are almost entirely without clothing. Among civilized people clothing occupies a position close to food in importance; custom and fashion have even caused us to rate clothing above mere actual physical needs and comfort.

To supply the articles of clothing of civilized life many objects from all parts of the world are drawn upon, including the common textiles, leather, rubber, fur, feathers, bark, paper, grasses, and so on. But in quantity used and in commercial value the most important are the textiles. In entering upon the study of textiles, then, we take up a subject of the greatest practical importance, one that merits more careful attention than has yet been given to it by either tradesmen or consumers.

The textiles.—The textiles comprise all materials that

are spun into threads, cords, or yarns, and then woven or knit into cloth. There are many such substances. They are almost invariably of fibrous or hair-like structure however; hence the raw materials are generally spoken of as textile fibers.

The textile fibers of industrial and commercial importance are naturally classified according to their origin as *vegetable, animal,* and *mineral.*

Vegetable.—The more commonly used vegetable fibers include cotton, flax or linen, jute, hemp, manila hemp, ramie and China grass, sisal, pineapple fiber, New Zealand flax, coir, Cuba bast, paper mulberry, Tampico fiber, palmetto fiber, straw of wheat, rye, barley, or rice, split palm leaves, osier willow splints, rushes, wood pulp, paper, grasses, seaweed, barks, moss, cotton wool, cotton silk, vegetable silk, and several others.

Animal.—The animal fibers comprise sheep's wool, goat's wool or hair, mohair from angora goats, cashmere from Thibet goats, alpaca from llamas, vicuna, hair of rabbits, beaver, cat, dog, horse, cow and camel, mulberry silk, and the wild silks.

Mineral.—The mineral fibers include gold and silver threads, tinsel, spun glass, slag wool, and asbestos.

The common vegetable fibers.—The vegetable fibers of greatest importance in textile manufacture are cotton, flax or linen, ramie, jute, and hemp. The ease with which cotton fiber can be transformed into yarn and its suitability for all forms of woven, knit, and lace fabrics, together with its cheapness of production, have caused it to take the leading place among textiles, until its production now about equals that of all other fibers put together. A little over a hundred years ago, flax was the most important textile in civilized lands; today it ranks fourth. Cotton, wool, and jute lead by large amounts.

Ramie.—Ramie and China grass (similar in quality and

usually considered to be the same, but really two different plants) are fibers of unusual serviceability. They possess great strength, luster, and the appearance that fits them admirably for dress goods, table linens, linings, fish lines, upholstering, and in fact for whatever purposes linens are used. Ramie has entered commerce through English manufactures in hosiery, knit goods, and to a certain extent in the manufacture of incandescent gas mantles. Recently, fabrics known as ramie linen have sprung into great popularity. Very fine yarns can be made from the fiber, although most of it is made up into coarse fabrics at present. In England and Germany, ramie is used rather extensively in the manufacture of union silk goods.

The chief drawback to ramie is the cost and difficulty of its production. No cheap or easy process has as yet been established for separating the fibers from the woody stems of the plants. At present the fibers are separated by hand, and although labor in the countries where ramie grows is cheap, the process is still too laborious and expensive. When mechanical devices shall have been perfected to do this work, we may look forward to a big development in ramie as a clothing textile.

Jute.—Jute is one of the cheapest fibers of all. Most of the world's supply comes from Bengal, India, and there its production is increasing rapidly. Its chief use is in the making of gunny sacking (especially used for covering cotton bales), burlaps, cordage, and matting. Some of the finer qualities are used in making shirtings and coat linings, and it is often mixed with wool, cotton, and flax in making the cheapest clothing materials and curtains. It is also mixed with silk in making cheap satins, velvets, and plushes.

It should be stated in passing that burlap may be made of jute, flax, hemp, or manila. The name burlap is a general one that is used for several kinds of coarse textile materials such as those used for merchandise wrapping, for

upholstering, and for floor coverings; the finer grades are often used for wall decorative purposes.

The jute plant has a tall slender stalk something like that of hemp. The fiber comes from the inner bark. It is easy to remove and to spin into coarse yarns. It is not, however, a very strong fiber and does not bleach readily like most other textiles. Furthermore, when exposed to dampness, it soon begins to rot. Were it not for this, jute would be used much more than it is for ropes and for other coarse textile purposes.

Hemp.—Hemp is the fiber used chiefly in the manufacture of rope and cordage. Like that of jute, the fiber comes from just inside the outer bark of its plant. This plant grows to a height of six to ten feet with stems up to an inch thick. The fiber is stronger than jute and stands the effects of water better than any other textile fiber; hence it makes a splendid rope material for use outdoors or in water. There are many varieties of hemp plants, and there is considerable difference in the quality of the fiber produced. Russia produces more hemp fiber than all other countries combined, but Italy produces the finest quality. In this country, Kentucky, Missouri, Illinois, and California lead in its production. Wisconsin produces a small but increasing amount each year, and the soil and other conditions of the state promise considerable increase in its production. The process of extracting the fiber is similar to that used in treating flax, as described in detail in the chapter on flax and linen.

Sisal.—Sisal or henequen is a fiber valuable for rope and cordage, and comes from the agave, a plant growing in Mexico and Yucatan. The century plant, which is known to many, belongs to the agave family, and is similar to sisal. The fibers come from the large, fleshy leaves and are easy to remove. Sisal is used extensively in the manufacture of binding twine in this country. It makes a strong rope,

but salt water destroys it rapidly; hence it is not used in ocean shipping.

Miscellaneous fibers.—Tampico fiber, sometimes called istle, is another hemp product used in making coarse cordage, brushes, and baskets.

Manila hemp is the strongest rope fiber in common use. It comes from the stem of a plant or tree belonging to the banana family, and is not a true hemp at all. The fibers, the longest in commercial use, are used in making rope, cordage, and the best grades of binding twine. A small amount of the finest fibers are made up by the natives of the Philippines into a cloth called "abaca." Practically all manila hemp comes from the Philippine Islands.

New Zealand flax, obtained from a plant belonging to the lily family, produces another good rope fiber, as do also the Mauritius hemp, bowstring hemp, pandanus, yucca, and aloe.

Pineapple fiber, obtained from pineapple leaves, is frequently used in the making of coarse cloths and cordage in China, South America, and certain parts of Mexico. The finer fibers are used by the native races in making a beautiful cloth of silk-like texture which they call "pina."

Coir is the fiber obtained from the outer husk of the cocoanut. The coir fiber runs in length up to ten inches and is of varying thickness and strength. The coarsest and stiffest is used in making brushes, the longest in making rope and cocoa matting, and the short curly fiber is used for packing material and upholstery stuffing. Coir rope is of value because it is not affected by salt water. It is not so strong as manila rope.

Cuba bast is sometimes used for wrapping cigarettes and for packing cigars.

The paper mulberry of Japan is put to the ordinary uses of paper.

Straw finds an important place in the manufacture of

straw hats, matting, and, in certain countries, as for example China, in the making of shoes and sandals.

The grasses, particularly the swamp wire grasses, have come to have a very important commercial place in the production of grass rugs suited for dwellings and porches. They are especially adapted for summer uses. Grass rugs are neat, cleanly, and cool in appearance. No floor covering has so great future trade possibilities as grass rugs. A considerable amount of this class of goods is made in Wisconsin at Oshkosh, Superior, and Racine.

Vegetable silks.—The cotton and vegetable silks are obtained from about fifteen varieties of plants and trees which yield fibers, generally attached to the seeds, as seed hairs. The largest group, including at least nine varieties, comprises the so-called "cotton trees" or Bombax cottons. These grow in Central America, Brazil, South Asia, the West Indies, India, Java, and certain parts of Africa. The fibers are known commercially in Europe as "kapok" and are worth from nine to sixteen cents a pound. Kapok is used chiefly in the manufacture of mattresses and pillows, and in upholstering. According to trade reports it has recently been spun and woven into cloth with excellent success.

Another group, the asclepias cottons, also growing in the tropics, produces seed hairs or fibers that have a very high silk-like luster, but these are so brittle as to be of little use in any textile that must stand wear.

The cotton silk tree of India, growing to a height of seventy to eighty feet, produces a seed hair fiber of most beautiful luster, but like that of the asclepias cottons, it is too brittle and weak to be of great use.

Wood pulp finds its place in the textiles principally in the production of certain kinds of artificial silk. It will be discussed in considerable detail under that subject.

Textile use of the animal fibers.—Hair, the natural cov-

ering of animals, has from time immemorial been used in the textiles. Certain kinds, such as the wool from sheep and from goats, have special properties or adaptability for spinning and weaving; others, such as rabbit hair or fur, cannot be spun, but can be used as felt. Wool finds its principal uses in five different branches of manufacture: worsteds, woolens, carpets, felts, hosiery, and knit goods. Silk, a product of the larvæ of several species of moths, is also classed among the animal fibers. Since both wool and silk will receive full attention in later chapters, they need not be discussed further here.

Gold and silver.—The mineral fibers have the least importance in the field of textiles. Gold and silver threads are used to a limited extent in fancy and costly fabrics, embroideries, and laces, and tinsel in cheaper decorative materials. To supplant the solid metallic filaments, which are difficult to handle and expensive to make, linen or other threads are covered with gilt or silver, and they serve the purpose as well as the solid metallic threads. In times past, say from 1500 to 1750, gold and silver were used much more than they are at present. Gold and silver laces, embroideries, braids, and cloths of gold and of silver were common among the nobility and very wealthy people. So much money was spent for this finery that laws were occasionally passed by different nations forbidding extravagant use of such goods, especially among those not of noble or royal blood. In those days men outglittered the women in gaudy colors, feathers, laces, and embroideries. Not until within the last hundred years have women come to outdo men in such matters of dress and style. Recently metallic textile fibers have been made by dipping cotton or jute threads into a chemical mixture which impregnates them with just enough of a given metal to give the thread a true, fine, metallic sheen. This product is used chiefly in embroideries, and dress-trimming novelties.

Spun glass.—Spun glass or glass cloth is another rather important mineral textile. Common glass is heated until it is as liquid as thick syrup. It is then drawn out into fine threads and, before being cooled entirely, is woven into fabric and given its proper shape. While melted, it may easily be colored and the finished product may be made very beautiful. But its usefulness as a fabric is confined to service where little or no bending is required, since the glass when cooled becomes as brittle as ever, and therefore breaks easily. It has a limited use for ornamental and decorative objects. Spun glass cloth is likewise used as a filter for strong acids which would destroy ordinary filter fabrics or papers. By different kinds of manipulation glass fibers can be made either straight like linen threads or curly like wool.

Slag wool.—Slag wool is produced from molten slag just out of the iron blast furnaces. This liquid slag, a waste product of the furnace, is turned into a closed chamber where strong currents of steam are forced into it, blowing it into fine particles which take fibrous or stringy shapes. These fall to the bottom of the chamber and are cooled in water. The resultant substance looks something like coarse wool. It is used chiefly as packing material.

Asbestos.—Asbestos is the most important mineral used in textile manufacture. It is found as a rock in various parts of the world, especially in northern Italy, northern Spain, and in Quebec, Canada. Most of the American supply comes from Quebec. This rock does not crumble under pressure, but comes to pieces in fine fibers of considerable length, flexible, and sometimes a little wavy. These fibers can be spun into yarn and made into fabric, or they can be pressed into a sort of felt-like cloth. The color of natural asbestos varies from pure white to gray, green, or rusty. It is difficult to dye artificially. The most noteworthy quality about asbestos is that it will not burn; hence asbestos

fabrics are usually made up into goods where that quality is desired, such as fireproof theater curtains and scenery, aprons, gloves, packing for steam joints and cylinders, lamp wicks, and lighting rings for oil stoves. The short straight fibers are rather hard to spin. In the manufacture of asbestos yarn, therefore, asbestos is frequently mixed with cotton to give the yarn strength. Later the cotton is removed by burning it out of the fabric, leaving the asbestos uninjured. Asbestos is also a very poor conductor of heat; hence it is frequently used in making table mats for hot dishes, packing for steam pipes and other heating apparatus to prevent the escape of heat where it is not wanted, and packing material for fireless cookers. In a large plant in the East the experiment of sending steam through an asbestos-covered pipe a mile long was tried. The boilers delivered 375 horse power of steam at 350 degrees Fahrenheit. At the end of the pipe the steam had lost only 10 horse power out of the 375—a striking proof of the remarkable non-conductivity of asbestos when properly applied.

CHAPTER II

HISTORICAL SKETCH OF THE TEXTILES

No one can tell when man first learned how to spin and weave textiles. That no great degree of civilization is prerequisite is evident when we see every savage tribe of the present making some kind of woven fabric. In any case, the oldest histories give us glimpses of men spinning, weaving, and knitting.

Linen.—Flax has been cultivated in Asia Minor for its linen fiber for more than four thousand years. Linen cloth, linen twine, and linen rope served man before iron and steel were utilized. People who lived in the stone age, the period when their implements were made of stone instead of metal, knew how to make flax or linen fabrics, remnants of which have been discovered in caves and in their buried cities. As is well known, linen cloth was the fashionable fabric of ancient Bible times. "Fine linen" was a mark of honor accorded only to the high and mighty. Mummies buried thousands of years ago in Egypt have been uncovered recently, and the coverings have been found to be linen cloth, made from a variety of flax slightly different from that now commonly grown.

For many hundreds of years Egypt was the greatest linen-producing country in the world. It was not until about a hundred years before Columbus discovered America that other countries were able to produce more than Egypt. Then every country in Europe began to cultivate flax, and until the latter part of the eighteenth century, when a

number of inventions made cotton fabrics cheap, linen was the most generally used textile. With the coming of cheap cotton, linen fell back into second place. Later it had to give place to wool also, wherefore it now occupies third place among the textiles used for clothing. In fact if one is to consider jute also, linen comes fourth.

Wool.—Sheep's wool and goat's hair have also long been used as textile fibers, and, of course, the skins from these animals have been used for clothing and tents for a still longer time. Sheep have been raised in practically every country, and the fiber is easy to manipulate and to work into textile products. The ancient Romans were skillful in spinning and weaving wool, and from them the people of northern Europe learned the art. About four hundred years after the birth of Christ (c. 400 A. D.) Roman soldiers in Great Britain started a wool-weaving factory at the British town of Winchester to supply themselves with clothing. From this factory the native inhabitants of Great Britain learned the value of wool, and began to spin and weave it for themselves. Later the wool of England became famous as an excellent product and was much demanded by other countries in Europe. Sheep raising succeeded better than the textile arts in England, however, in the early days; hence other countries bought its raw wool rather than the English wool fabrics. Several monarchs of England did their utmost to encourage the manufacture of wool. This manufacture was finally put upon a successful commercial basis by some Flemish immigrants who had fled into England because of religious persecution. Both wool workers and merchants came to London in large numbers during the reign of Henry II. Guilds were formed and London was given the monopoly of exporting English woolen cloths. From these beginnings several hundreds of years ago, London came to be, and is yet, the world's greatest wool market both for raw wool and wool cloth.

It is interesting to note that during the hundreds of years that man has raised sheep, the breeds have been slowly but remarkably developed. First the Romans, later the Arabian Mohammedans—or Moors, as they were called—and finally the Spaniards, evolved the wonderful breed of fine wool-producing sheep now known as merinos. Nearly all the finer wool now produced comes from sheep descended from these Spanish merinos.

Cotton.—Cotton was grown and made into cloth in India fully six hundred years before Christ. The textile arts were developed to an advanced point very early by the Hindoos. If one may believe the accounts of the fineness, strength, beauty, and lightness of the East Indian gossamers, the products of their hand looms, made long centuries ago, have never been equaled by any modern fabric.

Cotton was also known to the highly advanced South American Indians. Samples of good cotton cloths have been found in their most ancient tombs. Columbus found the Indians of the West Indies wearing cotton, and Cortez and Pizarro often saw it in use.

Cotton was known to the Greeks as "tree wool" and was fancifully described in some of their ancient books. It did not reach western Europe until about 900 A. D., when it was brought westward from Arabia by the conquering Moors. They introduced it into Spain, whence it gradually spread over the rest of Europe. There was some manufacture of cotton in northern Italy as early as the sixteenth century. From there it was communicated to the Netherlands. About the beginning of the seventeenth century there was religious trouble in Netherlands and Flanders. Some of the Flemish cotton manufacturers, spinners, and weavers were involved in these religious quarrels, and had to flee for their lives, as did the wool workers who came over from these countries to London. The cotton workers fled into England and settled in Lancashire where they

made a new beginning in cotton manufacture and succeeded from the start. With this hopeful beginning in the seventeenth century, Lancashire came to be the greatest cotton-spinning and weaving locality in the world. By 1641 the industry was well established in the homes of the people about the city of Manchester.

After the sixteenth century there was a steady and growing import of cotton goods from India into all parts of Europe; but about one hundred and twenty-five years ago Europe began to produce more than she needed and more than India had produced. By means of this East Indian trade in cotton and in many other goods, such as spices, silks, jewelry, and so on, European traders and merchants, particularly those in the East India Company, amassed great fortunes. For a time the English trade in Indian goods was a monopoly controlled by the East India Company and sanctioned by the king of England.

England's rise to supremacy in cotton manufacture.— At the time of our American Revolutionary War, England had so gained in manufacturing ability that she had become a strong competitor for the world's textile trade. It was partly because of England's policy of forcing the American colonies to buy her manufactured goods that the War of Independence broke out. In 1656 the English government had prohibited the American colonies from importing raw materials to manufacture into cloth. The law made bad feeling even at that time, especially in Massachusetts where, on the one hand, it acted as a stimulus to home manufacturing and, on the other hand, led to smuggling in foreign materials without paying the English tax. But the same policy was carried out by England at home also. It was thought perfectly legitimate to attempt to force her own people to buy English goods. In Scotland in 1775 there was formed a society for discouraging Scotch and English women from wearing cotton dress goods and robes made in

India, urging in preference the calicoes and lawns of Glasgow and Paisley, although the raw cotton in these British products came from India. In addition to any help that may have been received from following such restrictive measures, the natural advantages of England, such as climate, cheap power, and easy shipping facilities by ocean on all sides, caused England's textile industry to grow rapidly.

Progress in Cotton Production.—During the last hundred years the United States has forged to the front as a producer of both raw and manufactured cottons. At present the annual cotton crop is not far from 15,000,000 bales of nearly 500 pounds each. In the manufacture of cotton the United States is closely rivaling England, though England still has the lead. Within the last forty years Germany has advanced to third place in the manufacture of cotton.

The history of the production of raw cotton during the last twenty-five years records notable extension to new territory, as, for example, into China, Japan, the East Indies, Mexico, South America, and several parts of Africa. With increase of acreage there has also come the application of scientific agriculture to cotton production in the southern states. By means of proper selection of seed, introduction of new and improved varieties, better preparation of the soil, and wiser management of the growing crop, the total product has been materially increased. In many cases these improvements have resulted in the production of over twice as much cotton to the acre as was formerly raised.

History of silk.—Silk culture had its beginning in China, how long ago no one knows. There are records that seem to show that it was an important industry as early as 3000 B. C. There is a legend that silk culture was introduced by a Chinese queen, Si-Ling-Chi, from some country to the southwest, and that she herself raised the worms, reeled

the threads, and taught the people to do the same. She is now known among the Chinese as the "Goddess of the Silk Worms."

Silk production was introduced into Korea and Japan about 200 B. C. Later it spread to India and Persia, although the Chinese government attempted to keep all silk production to itself. To ship silkworm eggs out of the country meant capital punishment. It was from India and Persia that Europe first learned of silk. To a certain extent the new material was used in Roman times by the emperors and the women of the court, but it was not until about the tenth century that it became known generally over western Europe. Much of it came into use at first for church embroideries and royal robes, especially in the form of a silken fabric called sammet, produced in Arabia. Other silk fabrics introduced into Europe during the Middle Ages were known as ciclatoun, cendol, and sarcenet. Satins, velvets, and brocades were introduced in the latter part of the Middle Ages, all from the Orient.

Arabia was for a long time the connecting link between the Orient and the West, and from Arabia the Europeans got silk embroidery, gold brocade, silken curtains and mantles, and, by the fourteenth century, taffeta, which originally came from Persia.

The production of raw silk in Europe was begun in Italy before the middle of the twelfth century, and silkworms were raised in Spain by the Mohammedan Moors certainly as early as the eighth century. At one time the business was encouraged by the popes of the Roman Catholic Church, and later by the kings of France. Under such conditions Tours and Lyons in France became prominent silk-producing centers. By the seventeenth century, France supplied a large proportion of the silk goods used in the western world, a service in which she has led all other countries for most of the time since then. At present, Italy pro-

duces more raw silk than France, but France produces more of the manufactured product.

Silk culture in America.—Shortly after the settlement of America experiments were tried in raising the silkworm here. The first attempt was made in Virginia in 1622 upon the advice of the king of England, but the result was an utter failure. Later small amounts of raw silk were produced in Georgia, Connecticut, Pennsylvania, New Jersey, and Rhode Island. Connecticut was the least unsuccessful. During the Revolutionary War the industry died out and was not revived again until 1826. Beginning with that date and continuing for ten years there was great progress in silk production. Several societies of growers were formed, books published, new machinery invented, and in some states public funds were raised for the promotion and study of the industry. The United States Government published a document intended to be used as a manual of instruction for silk growers.

The silk craze of the thirties.—Previous to 1836, silkworms had been fed and raised on the common white mulberry leaves, but about this date someone introduced plants of the Chinese mulberry known as the *morus multicaulis* which, it was claimed, had some special properties and values for silk-growing purposes. Immediately all the silk growers in the country desired the Chinese mulberry. The new plant was so hard to get that a craze developed in which the price for the plants rose to fabulous sums, small cuttings selling for almost their weight in gold. Acres and acres were planted with Chinese mulberry trees, and great fortunes in silk production in this country seemed near at hand.

In 1837, however, a severe financial panic broke over the entire country, closing nearly every bank and driving great numbers of business men into failure and bankruptcy. Money became scarce. Those who had debts to pay found

it difficult to raise the necessary amounts. This panic of 1837 hit the silk and mulberry industries hard. Chinese mulberry plants so declined in value that they could be had for ten cents per hundred. Thousands of persons were ruined in this crash which lasted throughout the years of 1837 and 1838. Silk growing naturally received a terrible set-back, which was made worse by the severe winter of 1839, which killed nearly all the Chinese mulberry trees still to be found in the country. For several years no more silk was grown in the United States.

Many years passed before there came any revival of interest in this country in growing silkworms. In the meantime, manufactories sprang up here and there in the East, which imported from Europe all their raw silk. By 1860 there were no less than sixty-seven factories. There had grown up an importing trade, and business had ceased to look to domestic sources for supplies of raw silk.

The California silk craze.—In 1861 a Frenchman named L. Prevost began raising silk near San José in California. Prevost was something of a promoter and he soon interested a considerable number of California people in the industry. His plan, however, was to raise the silkworm mainly for the eggs rather than the silk fiber. The eggs were to be sold to French and other European silk producers. The California State Agricultural Society became interested in Prevost's scheme and aided in its advertising, and the state legislature passed a law offering a bounty to silk producers. But Prevost was more successful in promoting the idea than in keeping the venture going. What had developed into a good-sized silk-culture craze in California quickly collapsed when the would-be growers found that the silkworms required an immense amount of care, that they were subject to a number of destructive diseases, and that even the California winters were too severe for the worms when kept out of doors.

Recent attempts to produce raw silk.—Attempts to raise silkworms were made in Kansas in the boom days of that state, in the later seventies, but the droughts of the eighties stopped the silk culture there. About 1878 the Department of Agriculture in Washington became interested in silk culture, and in the years that followed made considerable effort to interest the people of various sections of the country, especially the South, in growing silkworms. By 1883 regular annual appropriations of money were made for the Department that it might study and promote silk growing. A reeling institution, or filature, was established at Washington, and cocoons were purchased by the government from all growers. Silk growing was revived in Kansas and California and extended into Louisiana and, later, in the nineties, to Utah.

Interest in silk culture on the part of the Department of Agriculture slackened in 1890, and it was not until 1901 that another effort was made to introduce silk growing. This time it was planned to start the industry among the southern negroes of the poorer classes. But even this scheme has not been found successful.

The coming of oriental silks into American markets.—Since the bursting of the *morus multicaulis* silk-growing boom of 1830 and the Prevost craze in California in 1860, and during the time of the more recent experiments just referred to, certain new factors have crept into the silk situation which at present seem to preclude for a long time to come the possibility of making silk growing profitable in this country. In 1854, Commodore Perry of the United States Navy sailed into the ports of Japan and made possible by national treaties the opening of trade with a country which up to that time had held itself aloof from all the rest of the world. It happened that Japan was a great producer of raw silk, which became henceforth one of its principal articles of export. Some years later, China,

the greatest silk-producing country, commenced commercial relations with the rest of the world. From these two countries there poured into Europe and the United States a stream of raw silk that speedily reduced the market prices of this commodity from nine and ten dollars to three and four dollars a pound. Japan and China were full of men and women, who, although working for daily wages of some eight to fifteen cents, were nevertheless expert in the care of silkworms. Against such conditions of cheap production the United States could do nothing. Even France lost ground, and today silk culture there is standing still, despite the help of French government bounties. In Europe, only Italy, with her cheap labor and excellent facilities for producing what is pronounced to be the best raw silk in the world, has continued uninterruptedly to cultivate the silkworm.

As soon as the Japanese and Chinese markets were opened to the world, many of the largest manufacturers in this country, as well as in France and Germany, established buying agencies in the midst of the raw-silk-producing areas. It was soon found that there was much waste of energy and of material in the ancient methods employed by both Chinese and Japanese in reeling the silk. This was remedied, so far as certain individual companies were concerned, by starting on their own account reeling factories, called filatures, and by training the native workers in methods of using the improved machinery and methods installed. Several American silk manufacturers now own filatures at Shanghai and Canton, the principal silk markets of China. More recently, Japan has started experiment stations and inspection systems throughout her silk-growing areas, aiming at improving the product to meet the demands of the markets of the United States and Europe.

CHAPTER III

MECHANICAL DEVICES FOR PREPARATION OF TEXTILES

The mechanical side of the textile industry has had an interesting and remarkably rapid development during the last hundred years, through the evolution of the modern processes of spinning, weaving, knitting, dyeing, and finishing.

Ancient methods of spinning.—The earliest method of spinning was simply to twist the textile fibers into a thread by means of the thumb and fingers, or between the palms of the hands, or sometimes, between the palm of the hand and the naked thigh. Evidently these processes were extremely slow; yet for ages, or from earliest history, these were the methods in use down to about the time that Columbus discovered America. During all this time the only implement used in spinning was a stick, usually about eight to twelve inches long, to which was attached the end of the thread which was being twisted, and upon which the finished thread was wound.

The primitive spindle.—This stick, the primitive spindle, was usually held in the right hand, while the mass of fibers to be spun was held in the left. A loose thread was formed from the fibers, drawn out to arm's length, and attached to the spindle, which was then whirled between the thigh and the right palm until the thread had been sufficiently twisted. Then the thread was wound upon the stick and refastened at the end; a new bunch of fibers was drawn out from the

left hand, twisted and wound on the stick as before; and so the process continued.

The spinning wheel.—As stated above, at about the time that America was discovered or probably a little later, a new method, and a much better one, came into use in Europe and spread rapidly throughout the western countries. This invention was the spinning wheel. It combined three important parts, the spindle to twist the yarn or thread, the distaff to hold the loose raw fiber, and a wheel, operated either by hand or by a treadle, to turn the spindle and wind the finished yarn. At first the distaff was held in the hand; later it was placed in the spinner's belt or girdle; but finally someone hit upon the bright idea of placing it on the machine, thus leaving both hands of the operator free to handle the loose fiber. Who invented the spinning wheel no one knows. The idea probably came from Persia or India, since these countries used spinning wheels much earlier than did the people of Europe. Furthermore Japan and China had used similar contrivances for hundreds of years before Europeans had dreamed of such an invention.

The form of spinning wheel just described was in constant use in the homes of the people almost down to our own time. Many now living in this country have seen the spinning wheel in use, and one can find, here and there, in old family homes and in museums, the spinning wheels that once whirred merrily in the making of woolen or linen yarns. A hundred years ago, no home was complete without a spinning wheel.

The spinning jenny.—In 1764, a man named James Hargreaves, a poor laborer of Blackburn, England, invented a machine which he called the spinning jenny, which twisted several threads at one time instead of the single thread of the common spinning wheel. In 1769, a spinning machine of different type was invented in Preston, England, by a barber named Arkwright. Both machines came into use

rapidly, especially Arkwright's, which made the better yarn.

The spinning mule.—Next came an improvement by Samuel Crompton of Bolton, who combined the good ideas of both machines and called his invention the spinning mule. Improvements have since been made in this machine from time to time, but the spinning mule is still in use today, although another sort of spinning machine called the ring spinner, invented in 1835 by Richard Roberts, is used rather more now for common grades of yarns. The mule is used principally for the finer grades of soft and fancy yarns.

Effect on textile industry.—These inventions had an immediate effect on cotton production. Lancashire sprang to the front in the manufacture of goods that had formerly come from India, such as calicoes and muslins, and by 1785 cotton cloth became as cheap as linen. Another important factor in the promotion of English cotton manufactures was the growing French fashion of wearing English cotton goods made up into clothing for both men and women. Though in France itself this custom died down during the dark days of the French Revolution and the hard times that followed, yet elsewhere the demand for the English goods became permanent. The cheapness and utility of these cotton goods could not be overlooked by the masses.

Recent improvements.—During the last fifty years the main improvements in spinning have been largely by way of increasing the speed and making the operations more and more automatic. For example, in 1851, one operator could care for about 50 spindles. Now the usual task is 125. Fifty years ago the spindles revolved at the rate of 5,000 turns per minute. The usual speed now is nearly 10,000 turns. Practical mill men claim that this is about the limit of improvement in this direction.

In this connection should be mentioned the immense improvements in the preparation of the raw fibers for the

spinning machines. Machinery now supplants all the old hand processes of cleaning out the dirt, sticks, and leaves often found in cotton, also of opening up the bales and of carding. Before the middle of the nineteenth century, machines were invented for so combing wool fibers that in the spun thread all fibers lie parallel. This made possible the production of worsted goods, which in the last fifty years has leaped forward tremendously. Recent improvements in combing machinery make it possible to comb with small waste almost any length of wool.

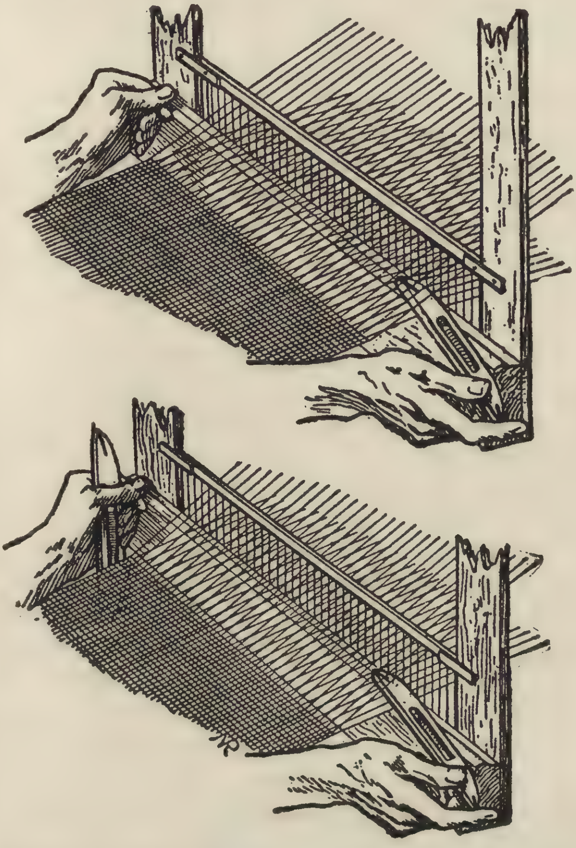
Combing has also been applied with success to cotton fibers, especially in making yarns for knit goods. For some time only sea-island and Egyptian cottons could be combed—that is, the longest stapled cottons—but recent inventions in combing machines take cotton staple as small as seven-eighths of an inch long. This length includes most common American upland cottons. There is, therefore, a big future for the textile trade in combed cotton goods, as well as in those of combed wools and other fibers.

Weaving.—Weaving in some form or other has been practiced by all peoples and from the earliest recorded ages. Weaving consists essentially of an interlacing of two sets of threads or cords running in directions at right angles to each other. The threads running lengthwise of the cloth are known as the *warp,* and those running across the warp are called the *woof, weft,* or *filling.*

Ancient forms of weaving.—Simple weaving processes are used by even the lowest savage tribes, especially in making mats and baskets and in interlacing the bark and twigs for huts or tents. Almost as universal is the making of some kinds of cloth out of woven goods. For this, the simplest arrangement used by the ancients, a method still employed by savage peoples, was the fastening of the warp threads between two convenient objects on the ground, and then weaving the weft or filling threads back and forth

A Pair of Hand Cards.

through the warp threads in the same manner as in darning. This gave the simplest form of the loom.



THROWING THE SHUTTLE THROUGH THE WARP SHED BY HAND.

The heddle.—The first improvement was a device by which alternate warp threads could be drawn away from the rest so that the filling could be passed through rapidly. This device, called the "heddle," was in its commonest form

a piece of wood the shape of a thin board and as long as the width of the cloth to be woven. In this board there were cut vertical slots several inches long at close intervals along the entire length of the board, and between each pair of slots at about the middle point, holes or "eyes" were cut. Alternate warp threads were passed through the slots, one thread through each slot, and the intervening warp threads were passed in due order through the eyes, one thread through each eye. On raising or lowering the heddle the warp threads running through the eyes were raised or lowered, while the warp threads running through the slots remained stationary. Thus part of the warp could be raised above or lowered below the rest of the warp and an open space made for rapidly passing through the filling or weft thread.

The shuttle.—The filling thread was carried through the two layers of warp threads by means of a shuttle which was thrown by hand, the thread unwinding from the shuttle or bobbin within the shuttle as fast as it moved forward.

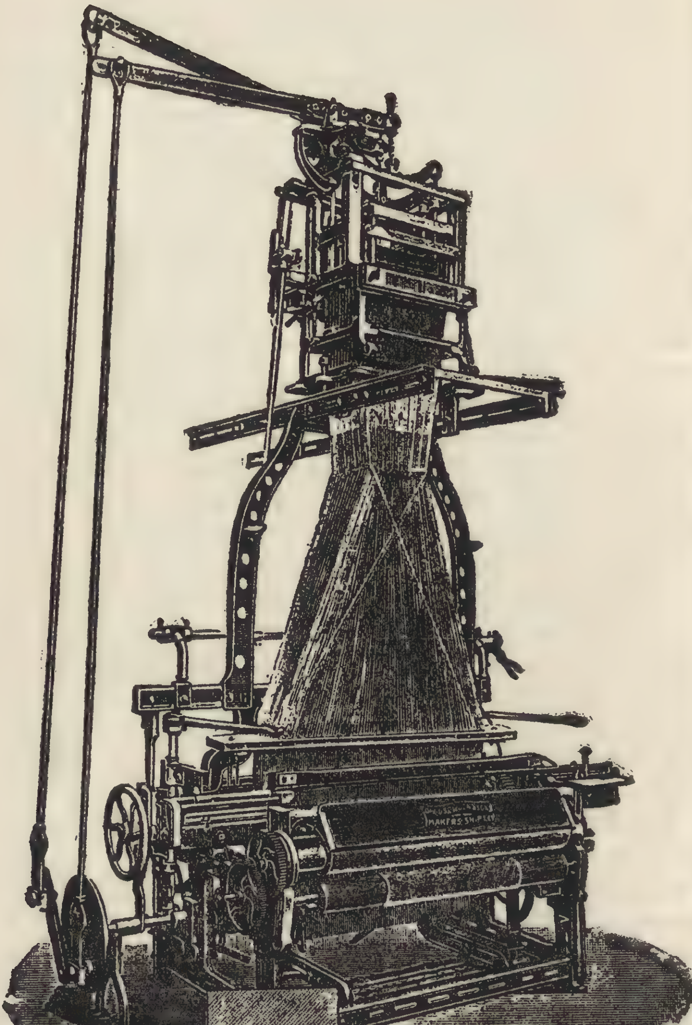
The reed.—The filling threads were drawn up closely into place by means of a comb or "batten," and later by an improvement known as the "reed." The ordinary loom to be found in most homes a hundred years ago consisted of a frame with a warp beam at one end upon which the warp threads were attached and wound, a cloth beam at the other end upon which the finished cloth was received and wound, two heddles so arranged as to be worked by foot treadles, a hollow shuttle containing the bobbin wound with filling thread and thrown by hand, and a reed to beat the filling thread up into place—all worked by hand. The part of the loom that raised and lowered the heddles was called the "harness." Though there have been great improvements in weaving and in the loom mechanism, the principle applied in this old-time loom is the same as the principle underlying the modern loom.

Flying shuttle invented.—The first improvement in the direction of increasing weaving speed was an invention for throwing the shuttle through the warp by a mechanical device instead of by hand. This invention, called the flying shuttle, was made in 1738 by an Englishman named John Kay. A few years later this machine had entirely taken the place of the old hand-throwing looms in the textile districts of England. In 1760, Robert Kay, a son of the inventor of the flying shuttle, added a device to the loom to hold several shuttles, each with a thread of a different color. This made possible quick changes in weaving in colors.

Improved looms.—During the same year, 1760, a new type of loom, known as the swivel loom, was introduced into England from Holland. On this loom it was possible to weave several narrow pieces of cloth, such as tape, ribbons, etc., at the same time. Shortly afterward came the invention of a loom with several heddles and harnesses, making possible the weaving of figures in cloth. This sort of weaving was still further improved when M. Jacquard of Lyons, France, invented the Jacquard loom, in which the raising and lowering of the warp threads is controlled by a complicated set of perforated cards which are made for each particular design or figure to be woven. In this loom practically every thread is under control.

Power weaving.—In 1785, an English preacher named Edmund Cartwright discovered the possibility of the application of power to the loom. Previous to this time all looms had been operated by hand. But the English producers looked askance at power looms long after they had adopted power spinning. It was not until 1820 that the hand looms began rapidly to make way for the steam-power looms.

Recent improvements.—There have been many improvements in weaving since the beginning of the nineteenth



JACQUARD LOOM.

century, but they have been largely in increasing the speed, decreasing stoppage time, and making the looms automatic so that they will run with little or no attention, and stop the moment anything goes wrong. For example, the stops made to change the shuttles when the filling of the shuttle bobbins is used up have been made unnecessary. An American weaver can now attend to from sixteen to twenty-four and even as high as twenty-eight high-grade automatic looms making twenty-seven- to thirty-six-inch wide cloth. When these modern looms are all supplied with their full quota of shuttles, the operator can leave them and go to dinner if he wishes, and the looms will run until some thread breaks, or until the filling in the shuttles has run out, and then they will stop instantly and automatically.

England tried to prevent other countries from getting models of her many textile inventions during the early years of the nineteenth century. Yet the English machines were duplicated in America. The English claim that the Yankees pirated their ideas; while the Yankees claimed independent discovery. At any rate, both spinning and weaving by power became known in this country before 1820.

Recent noteworthy inventions in looms are the high-speed automatic ribbon looms, silk label weaving machines (since 1903), and web looms for making suspender and garter webbing and shoe lacings.

Knitting.—Knitting differs from weaving in that it employs but one thread, or one set of threads, instead of two. Weaving machinery was invented before the modern looms but the vogue in knit goods is very recent, the people of this country using between three and four times as much per capita now as they did even twenty-five years ago. It is only within the last thirty years that knitting has changed from a home to a factory industry.

Knitting machines.—The first knitting machine, so far as known, was invented in 1589 by William Lee of Not-

tingham, England. Its use was forbidden, however, by Queen Elizabeth, because of the fear that it would destroy for many hand knitters the chances of making a living. It was not until 1816 that mechanical knitting was revived. At that time a circular knitting machine was invented and run by power. Yet knitting occupied only a small place in factory production for more than fifty years after that. Since 1870, however, the knitting industry has grown very rapidly in Germany, England, France, and the United States. All sorts of knit clothing are made for men, women, and children, and all varieties of yarns are utilized. The general character of the knitting machines of the present can be judged from the following kinds used in making simply the body part of a knit undershirt: flat, ribbed; flat, plain; full-fashioned flat, ribbed; full-fashioned flat, plain; circular, ribbed; circular, plain.

Then there are knitting machines for sleeves, wrists and ankles; and for hosiery, gloves, mittens, caps, leggings, and so on. Some knitting machines are made to produce a loose, elastic fabric, while others produce a hard, solid material. The former are known as spring-needle goods and the latter as latch-needle. Knitting has also been applied in a number of new ways, such as lining for rubber fire hose and lawn sprinkling hose, table padding, etc.

Dyeing and finishing.—The process of dyeing and finishing fabrics was greatly improved at about the same time that the great inventions were being made in the way of rapid and economical spinning and weaving of textile goods, during the last quarter of the eighteenth century and the first quarter of the nineteenth century.

Discovery of cheap dyes.—The soda bleach was invented by French scientists and introduced into England shortly after 1780. Indigo, logwood, cochineal, cutch, and several other "natural" dyes had been used for a long time, but some of these were very expensive and difficult to apply.

In 1856 an English chemist, H. W. Perkin, accidentally discovered that he could make a beautiful mauve color from coal tar, a product of practically no value at the time. A little later a French chemist discovered a way of making magenta from the same substance. These were the beginnings of one of the most wonderful scientific developments ever known, for now thousands of colors, shades, and tints are possible, all made from coal tar.

Making dyes from coal tars as a business has grown to tremendous proportions, especially in Germany. Thousands of workmen and hundreds of highly educated chemists are employed, and the yearly product is worth millions of dollars. Of the great number of dyes produced from coal tar, some are of little value while others are exceedingly fast and serviceable for textile use. Some are easy to apply, others more difficult, but all are comparatively cheap. By exercising care in testing the materials and the dyes in advance, by utilizing the chemical knowledge of the present, and by giving the proper time and pains to the processes of dyeing, we can now color any textile satisfactorily with coal-tar dyes. As a result, they have almost entirely taken the place of the old vegetable or natural dyes.

The Industrial Revolution.—The remarkable series of inventions which so rapidly revolutionized textile production was but one striking phase of that widespread "Industrial Revolution" which in both Europe and America, but more especially in England, characterized the period from 1760 to 1830. Not only were the textile and other industries affected; even more impressive was the change in home life and general social conditions.

The household industry.—Previous to 1760, textile making was essentially a home industry; that is, the entire work was done in the home of the worker, or, as he was then called, the manufacturer. The family was the unit of labor and the women and children were important assistants. All

work was done by hand. The head of the house did his own purchasing and selling of the raw and finished products. In the home the women spun the raw cotton, wool, or flax into yarn on the old-fashioned spinning wheels. One loom kept four or five spinning wheels busy. Often the family bleached and dyed the cloth and pressed it, or gave it whatever other simple finish was thought desirable. The family owned what it made, as well as the tools used in the making. There was comparatively little hiring for wages. Work, such as dyeing, done outside the home by some other family, was usually paid for with a share of the finished product. There were, to be sure, some wage workers, such as journeymen weavers, but the number was small as compared with the wage laborers under our present labor system. The most frequent break in the straight family unit was when boys were taken in from other families to learn the trade, to serve as apprentices; yet these apprentices were usually treated as members of the family. After some years they became fully conversant with the trade and became journeymen wage earners. Later most of them set up establishments of their own, in many instances marrying the daughters of the masters whom they had served as apprentices. Thus the household system went on.

Beginning of Factory System.—In 1771 water power was applied to the spinning wheel—a profitable innovation. Spinning factories sprang up along the water-power streams of Lancashire. Women in the homes began to lose their occupations at the old-time spinning wheel while the spinning factories began to employ both men and women to run the power spinning machines. Inevitably, then, the house industry system began to break down and the factory system of the present to rise. For the fifteen years during which water power was used, a number of towns sprang up near the waterfalls, whither people moved from their country homes to live near their jobs.

Movement to cities.—In 1785 Watt's steam engine was applied to spinning machinery. On account of its convenience and the cheapness of the coal from the near-by mines, steam power grew in favor, until in many places the water-power plants were closed and the towns around them deserted for the big cities with their steam-power factories. There was a large foreign as well as domestic demand for cloth, wages were considered good, and the so-called factory system became firmly established within a few years.

Changes in methods of labor.—But what a change had been wrought in the methods of production! No longer could the laborer own the tools or machines with which he worked. He no longer had anything to say about the product. He was now employed at a daily or weekly wage. Instead of doing everything required to produce the finished goods, from buying the raw material to selling the completed product, he did but one small subdivision of the work. A factory now had buying, producing, and selling departments, each with its own group of employees. In the producing department, this division of labor was carried to minute detail. With the introduction of automatic machines, the workers were frequently set at some one task that called for but a single movement of the hands, repeated thousands of times a day. Such division of labor, profitable from the manufacturer's standpoint, has been carried very far in modern plants. For example, in a modern tailor shop or clothing factory, the making of an ordinary coat requires about forty separate operations, that of a vest about eighteen, and that of the trousers twenty-eight. In making a corset in a modern factory there are some eighty-five or ninety separate processes; in the making of an ordinary pair of men's shoes, over one hundred and forty-five. The tailor of today makes only one-fortieth of a coat instead of a whole suit of clothes. The shoemaker

makes only one one-hundred-forty-fifth part of one kind of shoe instead of a whole pair of shoes as did the shoemaker of the past. And the same thing has taken place in practically all other manufacturing occupations. This minute division of labor was one of the characteristic results of the Industrial Revolution.

Big capital required.—Immense amounts of capital were brought together for running the modern factories. The corporation was developed as a suitable form of organization of this capital, and the markets of the world became responsive to the will of these great aggregations of capital instead of to the old-fashioned law of supply and demand under competitive conditions.

Attempts to cheapen cost of production.—In the severe competition that arose at the beginning of the factory system, lasting in some industries down to the present day, the managers began to seek all sorts of devices to cheapen the cost of production.

Adulterations.—They imitated and they adulterated, until a time came when cheapness seemed synonymous with nastiness. Pure-food legislation has been found necessary to keep greedy manufacturers from poisoning people by wholesale. There is now a strong movement for pure-fur laws and pure-textile laws. One state, Louisiana, has already passed a law making it a crime to sell shoes of which any part is imitation leather, unless a statement to that effect is stamped on the shoe. Similar bills have been introduced in several other states.

Cheap labor demanded.—Child labor has been profitable, since children can do much of the work in a textile mill that men and women had formerly done. In the early part of the nineteenth century children were sent to work twelve or fourteen hours at the cotton mills, when only five years old. The story of this period is in fact the darkest blot in textile history. The children were treated like slaves, han-

dled in herds, poorly fed, poorly clothed, and overworked in unventilated factories. Great numbers died. The survivors grew up uneducated and good for nothing, immoral and careless of every human custom and institution, a menace to society. More recently child-labor laws preventing such evils have been enacted in most countries, though not yet in some of our own states.

Evils of city life.—Other evils grew out of the factory system before people began to know how to meet them. Most of the people in the early factories came from country homes in which textiles had formerly been made. These old homes were broken up, their members scattered to the four winds. Only those too old or too young to work remained behind, and the children were soon ready to be sent to the cities to work. These people knew nothing of crowded city life. It was a far cry from the country home, its vegetable patch, the flower garden, the chickens, sheep, and cattle, to the crowded, many-storied tenement with high rents, and little sunlight or fresh air. The change was ruinous to health and character; the result was a more frenzied concentration on the one thing, to make money. Distrust and other unsocial feelings became frequent, and the struggle between capital and labor inevitable.

Such were the conditions of living in the textile industry, and they deteriorated rapidly. Health, strength, and morals suffered. The second generation became weaker than the first. Intemperance and vice grew frightfully. It looked for years as if civilization were headed towards anarchy or destruction.

Government regulation.—Governments have now recognized new functions in their relation to industry, and have established laws regarding sanitation, ventilation, and lighting in factories and in tenements. Hours of labor have been shortened for women and children. Compulsory education has been demanded. Dangerous machinery must be

so guarded as to prevent accidents. The problems of health and morals are beginning to be considered as community problems instead of individual matters as they were before the days of the Industrial Revolution.

General results of the Industrial Revolution.—The Industrial Revolution brought changes that have benefited humanity. It made it possible for the masses of the people to be comfortably clothed and fed. It multiplied the producing efficiency of the individual. Machinery now does the drudgery formerly done by hand. None the less the Revolution brought evils too—needless ones, to be sure, but not yet wholly eradicated. People did not know how to prevent them; they did not even know of their existence until many lives had been sacrificed and much misery caused. Invention of machinery and of improved mechanical processes so rapidly changed production that people were not able to make the necessary social changes fast enough to keep pace with the industrial development.

Early attitude towards machines.—One of the most interesting phases of the Industrial Revolution was the antagonism of the workers themselves towards the great improvements in the machinery. It has already been noted that in 1589 the inventor of the knitting machine was forbidden to use it. The feeling was then common in all Europe that labor-saving machinery would do more harm than good. For example, a ribbon loom that would weave four to six pieces at one time was invented in 1529 by a German in Danzig. History reports that the inventor was secretly drowned at the command of the mayor of the city.

In 1630 or thereabouts, a similar labor-saving loom appeared in the city of Leyden, Holland. The weavers of the city rose in a riot, and the town council burned the new devices in the public square. Many other towns had similar experiences both on the continent and in England. At one time the German emperor forbade the use of automatic

devices on looms, and not until 1765 did weavers dare to use them openly in Saxony. Hargreaves' first spinning jenny was smashed by his neighbors. A machine for dressing wool was invented in 1758, and as soon as the workmen near-by discovered its purpose, they came in and burned it. Hundreds of attacks like these followed in England. In 1810 there was an insurrection led by an idiot named Ned Lud, so the histories state. His followers, called Luddites, marched from factory to factory, and from town to town, and smashed and burned every form of modern machinery that they could find. This great disturbance was finally suppressed by the government but only after considerable bloodshed. The workmen instinctively felt that the machine was taking away their work, thereby depriving them of the means of getting a living. In a measure this was true. Thousands of men, often skilled workers, found themselves out of a job when a machine was invented that could do what they had done. Often the new machines required only a small boy or girl to tend them. It took time to find and master other kinds of work. On the other hand, to the human race as a whole, the machines were a great blessing, cheapening the necessities of life, and making it possible for even the poorest workman and his family to have goods which until then only the rich man and the noble could possess.

CHAPTER IV

COTTON PRODUCTION

The cotton fiber.—The cotton fiber comes from the seeds of the cotton plant. It varies in length from one-half inch up to two and one-half or even three inches, according to the variety and to the conditions under which it is raised. The great volume of cotton in the world's markets averages about an inch in length. When examined under a powerful microscope, a single fiber appears to be flat like a ribbon with a ridge at each side, but instead of lying flat like a ribbon the fiber is twisted many times so that it looks like a spiral. This twist in the fiber, together with the ridges at the edges, helps materially in spinning the fibers into a thread, for the fibers are entangled in each other's spirals, and this makes the thread hard to pull apart without breaking.

Composition of cotton.—Chemists tell us that the cotton fiber is composed of a substance called cellulose. This substance is found in all plants. All vegetable fibers such as linen, hemp, jute, and so on are principally composed of cellulose. It is the most important part of wood and straw and, therefore, of paper. The pulp of cornstalks and the fibrous parts of leaves are mainly cellulose. In this substance a chemist can point out a number of well-defined qualities found in neither wool nor silk; therefore from the science of chemistry we can learn tests to determine whether or not a fabric has cellulose in its construction, and distinguish it definitely from wool and silk. But to tell

Cotton plant, showing height.

Cotton bolls.

whether the cellulose in the fibers under examination comes from the cotton plant or from some other plant requires an entirely different test.

Cotton belongs to mallow family.—The cotton plant is a member of a big family, the mallows. It is related to the garden hollyhock. The cotton blossom closely resembles that of the hollyhock. The technical name of cotton is *gossypium.*

Numbers of species.—There are several species of cotton plants. Some authorities claim there are as many as twenty-eight; others distinguish only four distinct species, each showing slight variations. There are in all about two hundred varieties of cotton grown for the fiber, but it seems fairly certain that they are all members of one or another of the four great species of cotton.

Names of cotton species.—These four kinds of cotton are: herb cotton, called by botanists *gossypium herbaceum;* shrub cotton, called *gossypium hirsutum;* tree cotton, *gossypium arboreum;* and lintless cotton, called *gossypium barbadense.*

The names of the cotton plants suggest their varying heights. The *gossypium herbaceum* or herb cotton grows to a height of from two to four feet. The *gossypium hirsutum* grows to a height of about six feet, and is the commonest species, comprising most of the so-called upland cottons raised in the United States. The *gossypium arboreum* grows to a height of from fifteen to twenty feet. The *gossypium barbadense* differs from the other cottons in that its seeds are not covered with the little hairs or lint found on other cotton seeds, especially upland varieties. Its fibers are longer than those of the other species, and are therefore more valuable. The sea-island cottons of the United States are the best examples of this species.

Conditions favoring growth.—The cotton plant can be grown only in a warm climate. It takes at least a six-month

summer for the seed to become a plant and for the plant to produce a crop of cotton. The cotton plant is a perennial; that is, it continues to live for several years like most shrubs and trees; but it is easily killed by even the lightest frosts. In every cold cotton country, therefore, new seed must be planted every year. Even in tropical regions, a better crop is produced by such annual replanting than by allowing the old plants to grow and produce crops year after year.

Where produced.—The principal cotton-producing countries in the world are the United States, India, and Egypt. The United States alone produces about six-tenths of all the cotton in the world. India produces about two-tenths, and Egypt, one-tenth. Several other countries, such as Peru, Brazil, China, Japan, Arabia, Persia, Russia, West Africa, Algiers, West Indies, and Mexico, produce a small amount each, making up the remaining tenth of the world's supply.

India, China, and other Asiatic countries produce the herb species of cotton, *gossypium herbaceum*. The shrub species, *gossypium hirsutum,* is, as has already been stated, the common American cotton. It is also grown in the West Indies and Mexico. The tree cotton, *gossypium arboreum,* grows in India, China, Arabia, and some other Asiatic countries. Very little cotton enters into the world's commerce from this species. The *gossypium barbadense* is raised in the West Indies and on the islands and lowlands near the coast of the South Atlantic and Gulf states. This species, ordinarily called sea-island cotton, has been transplanted to various parts of the world, as, for example, Egypt, Australia, and the Fiji Islands; its cultivation has also been tried with some success on the uplands of the southern states and in the irrigated regions of the Southwest.

The South American cottons, generally called Brazilian and Peruvian cottons, are considered to be varieties of the

gossypium hirsutum. The fibers differ widely in the many varieties of this species, and serve quite different uses in textile manufacture. Peruvian cotton is, in general, harsher and stronger than Brazilian cotton. It is so much like wool that it is often used to mix with wool.

General qualities of the principal kinds of cotton.—The principal qualities that make cotton fiber valuable are its length, strength, fineness, and color. Other qualities are considered in the market, such as pliability, regularity, smoothness, and cleanliness, but those first named are most important.

Sea-island cotton.—Sea-island cotton is by far the best. Its fibers average from one and one-half to two and one-half inches long. It is silky in appearance and of fine color. This fiber is, therefore, used in making the finest cotton goods, such as sewing thread, lace, gauze, fine muslins, silk mixtures, and silk imitations.

Egyptian cotton.—Egyptian cotton, especially of the transplanted sea-island variety, comes next in these qualities. Its fiber averages from one and one-fourth to one and one-half inches in length, and its color ranges from white and glossy light to yellow. It also is used in making spool cotton, silk imitations, and the finer fabrics. Great quantities are imported into this country every year, and are combed and spun into yarns for fancy cotton knit goods, such as the better grades of underwear and hosiery.

Peruvian cotton.—Peruvian and Brazilian cottons have a fiber almost as long as Egyptian cotton, but they differ in several other qualities. Peruvian cotton has a harsh and wiry fiber. It looks and feels more like wool than any other cotton; hence it is used very generally in the manufacture of wool mixtures, especially where it is desired to preserve an "all wool" appearance. Brazilian cotton is similar, although rather less harsh and woolly.

Upland cotton.—The American upland cottons come next

in the scale. The fibers run from three-fourths to one and one-fourth inches in length, depending upon the variety, the kind of soil upon which the plant is raised, and the care given to production by the cotton farmer. Poor soil and poor cultivation produce a short fiber. The upland cottons furnish most of the supply for the great staple lines of cotton goods, such as ginghams, calicoes, sheetings, shirtings, and so on.

India cotton.—The India cottons rank somewhat lower than the American upland in length, strength, and other qualities. They are therefore used in making still coarser cloth yarns than the American cottons, as, for example, coarse sheetings, shirtings, denims, and drills.

Variations in grade.—It should be understood that there are several varieties of cotton produced in all of the cotton-raising countries, and that there are great differences in soil, climate, and methods of cultivation that make differences in the fiber. Although we have spoken of sea-island cotton as the best, a certain part of even this kind of cotton that comes to the great cotton markets of the world sells for less than good American upland cotton, when, as sometimes happens, the former is of poor quality, or in damaged condition. Egyptian cotton is, next to sea-island, the finest cotton in the world, but some cotton from Egypt, especially from the upper part of the Nile Valley, is no better than the India cottons. The fancy Egyptian cottons come from the lower Nile where the soil is very rich, because the annual overflow of the river and the irrigating systems keep the soil in the best possible condition. Outside of this well-watered region, Egypt raises some cotton, but not of the best grades. India produces more than a score of varieties of cotton, some of which are very poor. Most of them, however, average just a little below that of the American uplands, while a few are as good as the Egyptian. American cottons vary greatly. What are known as the Peeler,

Allanseed, Georgia, and Orleans cotton varieties rank considerably higher than Texas or Mobile cotton.

Improving the cotton.—The introduction of better methods of agriculture in cotton-growing areas is everywhere improving the quality of the fiber as well as the quantity of the yield. There is probably no reason other than the ignorance of the Hindu cotton farmers that prevents them from raising as good cotton as do our American farmers. It is noteworthy, too, that American cotton production is leaping forward rapidly wherever agriculture is being made scientific.

One method of improving the yield of cotton in a given area is the introducing of, and experimenting with, varieties of cotton from other lands. For example, sea-island cotton has been tried on Georgia uplands with considerable success. It has also been introduced into Egypt, Australia, Brazil, and elsewhere. Although sea-island cotton does not produce fiber two inches long on Georgia uplands, it nevertheless produces a better grade of cotton than the common upland cotton. Egyptian cotton, when brought to the United States, has been found satisfactory in certain southern lowland areas, also in irrigated regions in Arizona. The result of all this experimenting will finally be that each kind of cotton will be grown in the parts of the world where it can grow best, and where it will produce the most valuable fiber.

Cotton culture.—The cotton plant likes a good soil, deep, rather loose, medium grades of loam seeming the most satisfactory. It requires much moisture, but the soil must not be wet or mucky; hence it does best only when the land is well drained and has frequent rainfall, especially during the growing season. It rarely flourishes in a very windy section. Warm, balmy breezes, plenty of rainfall, good rich soil—these are the chief requisites.

Soil exploitation.—Cotton is hard on the soil. Several

thousands of acres formerly under cultivation in the South have been abandoned because of impoverishment of the soil. Much of this has been due to poor methods of farming and to failure to return to the soil the elements taken out by the cotton. It has been discovered that the cotton fiber takes very little plant food, but the cottonseeds draw heavily from the soil. In view of this fact, cottonseeds, and especially cottonseed hulls, are often used as fertilizers on land used for cotton growing.

Methods of planting.—In the southern states cotton is planted in March or thereabouts. The ground is prepared by plowing and harrowing, and then the seeds are sown in rows four feet apart. When the seeds have sprouted, laborers go down the rows thinning out the young plants so that the remainder stand about eight to fourteen inches apart. After this begins the cultivation, which somewhat resembles that given to corn. In days before the Civil War (1861-1865), and for some time following, all labor about the cotton field, such as planting and cultivating, was done by hand by negroes. On the larger modern farms everything is done by machine, save thinning out the plants, which is still done with a hoe.

Cotton losses on farms.—Cotton grows most rapidly during the months of June and July. The plants blossom and then begin to grow the bolls that contain the seed and the fiber. Each plant has several of these bolls, in fact many more than ever ripen and can be collected. Only about a quarter or a third actually ripen; hence there is a tremendous waste of nature's energy in producing a cotton crop.

The cotton boll weevil.—There are other great losses to which the cotton crop is subject, such as from plant diseases and destruction by insects. It is estimated that there is an annual loss of more than $40,000,000 per year due to one insect alone, known as the cotton boll weevil. This insect attacks the cotton bolls before they are ripe, destroying the

fiber. The ravages of this pest are widespread in the South, and the area affected seems to be growing. The cotton boll weevil originally came from Mexico over the Rio Grande River into Texas. It slowly spread throughout Texas and then into Oklahoma, Louisiana, Arkansas, afterward crossing the Mississippi into the eastern cotton states. During the last few years, the agricultural colleges of the South and the United States Department of Agriculture have made every effort to discover some means of killing off the weevil. Poisons have been tried with no success. One of the best plans so far hit upon has been the importation from Mexico of other insects and ants that were found to be enemies of the cotton boll weevil. Birds that eat the pest have been protected. The farmers are being taught to plant their cotton earlier so as to get the cotton bolls along so far as to be beyond the injury of the weevil before the season when the insect does the worst damage. Hardy varieties of cotton have been bred, and the cotton crop has been considerably increased by scientific methods of farming, even in the worst infested districts.

Strange as it seems, therefore, the cotton boll weevil has had much to do with improving methods of farming and making the farmers more intelligent. Before the trouble with this insect began, cotton raising was carried on in careless fashion. Agricultural education was not thought of. Farmers would not attend the farmers' institutes nor would they read agricultural papers. But when the weevil began to destroy their crops year after year, threatening to starve the people out of the country, there developed a strong interest in what schools and experiment stations had to say about farming.

Cotton picking.—The cotton bolls begin to ripen about the latter part of August and then the picking begins. The bolls do not all ripen at the same time, not even on the same plant. Those on the under sides and nearest the bot-

tom are first ready for picking. Because of the irregularity with which the cotton bolls open, it has been difficult to invent a cotton-picking machine. Although there are several types of machines in experimental stages advocated as offering success, the South still picks the greatest part of the crop by hand. The cotton-picking season lasts from August to December, or about one hundred days. Each field is gone over at least three times. The pickers are for the most part negroes, men, women, and children, many of them coming out of the cities just for the season, thus to earn a better, though brief, wage. Employers of labor—factory hands, day laborers, waiters, waitresses, cooks, kitchen girls, and household help of all kinds—state that when the annual cotton-picking season comes around it is very difficult to keep their help. There is a rush for the cotton fields, followed by a return to the cities at the end of the season.

The pay of the cotton pickers is from forty-five to fifty cents a hundred pounds. Many pick no more than this amount in a day; yet good pickers average about three hundred or even more pounds a day.

The cotton fibers and seeds are pulled out of each boll and dropped into a sack that the picker carries suspended from his shoulder. Whenever the sack is full, the picker empties it into a large basket set apart, and then returns to his row. When the day's work is over, the picker's baskets are weighed and the amount marked down to his credit by the farm manager.

Hauled to the gin.—After the cotton has stood in the baskets or has been laid in the sunshine awhile to allow it to dry out, it is loaded into a wagon and hauled from the field to the cotton ginnery. This is the place where the seeds and fibers are separated and the fibers compressed into bales. If his farm is large, the farmer may own his own gin; the majority, however, haul their cotton to gin-

neries whose owners charge a certain toll for ginning the cotton and baling it. The latest statistics show that each ginnery in the South serves on the average about thirty farmers.

The cotton gin.—The cotton gin is a machine that pulls the fibers from the seeds to which they are attached. It was devised in 1792 by an American, Eli Whitney. Previously, the fibers were pulled by hand, and no one could clean more than half a dozen pounds of cotton a week. The modern gin can handle 5,000 pounds a day. The wonderful development of the cotton industry would not have been possible without this invention, nor is it likely that without it America would have become a great cotton-producing country. But the gin made cotton king; by its means Southern slavery became profitable, and Lancashire, England, almost at a bound, took first place in the world's cotton manufacturing. Simple inventions sometimes have tremendous significance in social and economic life; the cotton gin is a most noteworthy instance of this truth.

Cotton lint and seed.—At this point the story of cotton divides, as we trace first the course of the cottonseed and then that of the fiber. Although in this study we are not primarily interested in the utilization of cottonseed, it is of interest to glance at this product and its uses.

Cottonseed products.—It has already been said that the cottonseeds, or parts of them, are used for fertilizing the cotton-growing fields. But only within recent years has this been done. Forty years ago cottonseed was, to the minds of the cotton grower and the ginnery operator, a nuisance that must in some way be got rid of. People used to throw this by-product into the rivers. Unfortunately the seed disagreed with the fish; wherefore the inhabitants farther down the streams began to complain of dead fish and the decaying cottonseed in the water. Thereupon the cotton men tried to burn the "waste product," but it would

not burn well. And if they merely left the pile out in the open air, in the course of time decay would set in and cause an unpleasant odor.

But modern progress lets few problems of waste products be unsolved; finally it was discovered that cottonseed contains a rich oil that can be utilized in a number of ways. Cottonseed has ceased to be a nuisance; every part has a definite value. The seed is now hauled from the ginnery and sold to the producers of cottonseed oil, who first strip off all the little fine hairs that the gin did not get. These "linters" are used in making cotton batting, wadding, felt, and also coarse yarns. Next the lintless seeds have their outside portions, the hulls, stripped off by machinery especially constructed for that purpose. Much of this material is used in paper making. Some of it is used as fuel in running the engines in the cottonseed oil factories, the ashes being afterwards used as fertilizers. Some of the hulls are ground into cattle food, and are often mixed with wheat bran. A secondary product is thus derivable—manure from cattle fed with this food, which is of high value to the cotton farms. Finally the cottonseeds, stripped of lint and hulls, are put in a heavy compress and all of the oil pressed out. What is left is known as cottonseed oil cake, or "oil cake" for short. Oil cake is ground fine and used both as cattle feed and as a cotton-field fertilizer. As a cattle food it is sought after, especially by farmers who have made farming a science. Great quantities of oil cake are shipped annually to European countries, especially to those noted for dairying, such as Denmark and Holland.

Cottonseed oil.—The oil pressed out of the cottonseeds is purified and made into salad oils. Mixed with beef fat it makes a cooking compound called by various names. Mixed with kerosene it makes miner's lamp oil. It is also combined with various soap alkalies in making toilet and laundry soaps.

Cottonseed oil as food.—Cottonseed oil is rapidly becoming a staple food product. Cooking fats containing cottonseed oil are increasingly used. Before the pure-food law was passed by the United States Congress, cottonseed oil almost supplanted olive oil in this country, boldly assuming the title of "olive oil." Such imitation with intent to deceive is now, of course, illegal. Cottonseed oil is rapidly coming into use upon its own merits as a cheap and nutritious food. It is interesting to note that its use is rapidly spreading in the olive oil producing countries, Italy, Spain, France, Greece, Turkey, and Asia Minor. Olive oil, a staple food among the people of these nations from time immemorial, is being replaced among the poorer classes by the cottonseed product. In some of the countries, no laws have yet been passed preventing dealers from calling it olive oil; hence it is often sold and bought, unsuspected, under the false name.

The cotton bale.—We have seen how the cotton fibers are separated from the seeds and baled at the ginnery. A hundred pounds of cotton from the fields yields about sixty-six pounds of seed and only about thirty-four pounds of fibers, or lint. About 500 pounds of lint are compressed into each bale. The amount varies from 300 to 900 pounds, but the average is not far from 500 pounds. The standard American bale measures fifty-four inches high, twenty-seven inches wide, and twenty-seven inches deep. The Egyptians put their cotton up in bales weighing 700 pounds. The East India bale weighs about 400 pounds, while that of South America averages some 250 pounds.

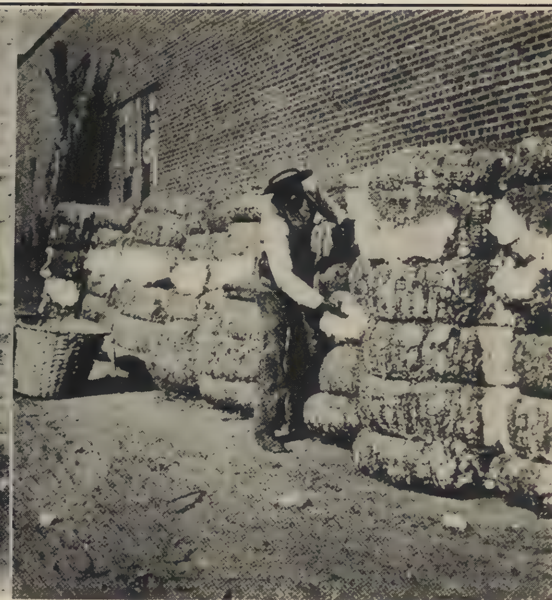
The bale is usually rectangular. There is another kind of bale, known as the Bessonette bale, shaped like a cylinder or barrel; this is said to be rapidly coming into use because of certain advantages it has over the angular bale in shipping and handling. It occupies less room, since it is more tightly compressed, but some cotton spinners object to it

because they claim the fiber is damaged by the heavy pressure.

In the baling press the cotton bale is covered with jute or other coarse cloth bagging and then bound with sheet-iron bands. This covering keeps the cotton clean while it is handled and shipped.

Poor bales from America.—American growers have been frequently accused of carelessness in baling cotton. Such coarse, poor bagging has been used that it has often been torn to pieces before the cotton reached the manufacturers; consequently the cotton lint has been soiled and spoiled. English spinners have been the loudest complainers, claiming that of all cotton imported, that from America came to them in the worst condition. Very little was done to correct this evil until 1906. During the cotton season of that year, the Lancashire Cotton Manufacturers' Association sent a commission from England to study and report upon the American methods of handling, baling, and shipping. The members of this commission traveled over a large part of the cotton belt in the South, attracting considerable attention among American cotton farmers. They finally made numerous recommendations for improving the handling of the cotton, suggestions which the cotton growers are now beginning to follow with profit. But much of the permanent bettering of cotton production, including the handling of the cotton, is due largely to the constant agitation and education of the farmers by the agricultural colleges, the farmers' institutes, and the publications of the United States Department of Agriculture. These forces have brought such results as the doubling of the cotton crop on a given area, as well as improving the quality.

Soft and compressed bales.



Gathering samples.

CHAPTER V

COTTON MARKETING

The first exchange.—After the cotton has been baled, it is ready for the market. The cotton farmer of the South may sell to some local storekeeper who makes a business of buying cotton, to some local cotton buyer or factory, to some cotton dealer located in a large cotton concentration point, to traveling buyers sent out by cotton merchants or manufacturers from the large cities, or he may perhaps sell direct to the cotton spinning mill if it is conveniently near so that he can make arrangements for transportation. In any case the farmer hauls the cotton bales to town and whoever buys the cotton grades it by examination of the bales and fixes the conditions of the first exchange.

The cotton farmer and his storekeeper.—The Southern cotton farmer has been in the past and is yet, to a very large extent, in a peculiar position. The majority of both the white and colored farmers are very poor and hardly ever have enough money ahead to supply all their needs during the months before the cotton is ready for market. Hence the cotton farmer often needs a considerable amount of credit extended to him by someone. These necessary advances are usually made by some local storekeeper who agrees to grant the credit on condition that the cotton be turned over to him in the fall. The advances consist largely of groceries and clothing for the cotton farmer's family, a few tools, and enough cash to pay the pickers and ginners. During the summer this debt to the storekeeper rolls up.

When the cotton is finally hauled in, the merchant takes it, grades it, and pays for it; any difference that may then exist between the value of the cotton at the storekeeper's price and the cotton farmer's debt is squared by a cash payment to the farmer. When the cotton crop does not equal in value the amount of the debt, the farmer simply ties himself up to the storekeeper for another year, hoping to get a crop the next season which will more than make up for the current loss. In this way it sometimes happens that cotton farmers are virtually tied to a storekeeper for years at a time. Many evils characterize this system. The storekeeper frequently loses part of the amount due him, while the cotton farmers sometimes feel that they are both overcharged for the goods they purchase and underpaid for the cotton they bring in.

At many points the system just described is breaking down. Recent advances in agriculture and interest in better methods of marketing have caused many of the southern cotton farmers to free themselves from the local storekeepers by supplying their own funds through savings. In many cases when loans are necessary, they are made by cotton merchants or factors; occasionally by coöperative associations of the farmers themselves.

Tenancy.—Many cotton farmers in the South do not own their farms, and must rent from some large landholder. The plantations before the Civil War often contained hundreds of acres cultivated by slaves. Since the war these plantations have in many cases remained under the same ownership, while the management has been left to tenants who take a few acres each. Some of these tenants raise cotton on shares, while others pay so much an acre for the annual use of the land. Often the plantation owner extends credit to stake the cotton farmer during the growing season, thus making the tenant responsible to him rather than to the local storekeeper or other person. At the end of the

season the cotton is turned over to the owner of the plantation; he pays the farmer any surplus over the charges for rent and expenses.

The tenant system of the South has not proved successful in developing a better type of agriculture. Where the tenant system is strongest, the methods of cultivation are as simple and knowledge of scientific agriculture as meager as before the Civil War. Recently, however, things have been improving in many regions. The larger plantations have begun to be divided, enabling the tenant to buy his own farm. With ownership has come a desire to get better results and a consequent greater interest in the newer ideas of scientific cotton farming. As a result, the future of cotton farming in the South looks promising for the small farmer.

COTTON GRADING

Whether the farmer sells to a storekeeper or to some other cotton buyer, the sale is not simply a transfer of so much cotton at so much a pound. Before the buyer invests he must know what *quality* of cotton he is getting; hence the cotton must be graded.

Grading cotton is of the utmost importance in both marketing and manufacturing. The buyer's usual method is to cut a slit through the bale wrappings and pull out a handful of the lint, upon which judgment will be passed. Sometimes samples of the lint are taken from two sides of the bale. These samples are carefully examined by sight, touch, and smell. The length and consistency of fiber are noted; the coarseness or fineness of the fiber is considered, and also its breaking strength. Since the cotton is bought and sold by the pound, it is necessary to determine if it contains substances which unduly increase the weight, such as dirt,

leaves, or undue moisture. Some moisture is always found in cotton fibers, but the amount should not average more than two or three per cent. of the total weight. If there is more moisture than this, the cotton sells for less. Both dead and unripe fibers are objectionable and lower the grade. Fibers damaged by frost or by insects are also of poor value. Finally the buyer considers the color and luster of the fiber. Upon the basis of all of these considerations, the grade of the cotton is determined. The bales are weighed; a certain percentage of the total weight, usually four per cent., is taken off for coverings and dirt; then the farmer is paid for the net amount of cotton. The usual test for moisture is simply by feeling. Any mildew is detected by its odor.

Chance in grading.—Cotton grading is more or less imperfect, and there is considerable play of chance in grading a bale. One bale of cotton contains the fiber from say two and one-half acres of land. Almost certainly there are great variations in the cotton, due to differences in the land. If the sample comes out of the best cotton, the bale brings a higher price than if the sample happens to be of the poorer cotton therein. A good many mistakes are possible in grading cotton. Any two graders, even if expert, seldom grade cotton alike, and it is by no means certain that the same grader could twice grade the same cotton in exactly the same way. The difficulty is often complicated by incompetence and sometimes by dishonesty.

The standard grades.—After the length and the strength have been established, the degrees of color, luster, and cleanliness give rise to thirteen distinct grades generally recognized in all cotton markets in this country. These from highest to lowest are as follows:

1. Fair
2. Strict middling fair
3. Middling fair
4. Strict good middling

5. Good middling
6. Strict middling
7. Middling
8. Strict low middling
9. Low middling
10. Strict good ordinary
11. Good ordinary
12. Strict ordinary
13. Ordinary

Of the grades in the above list, those designated as "strict" are commonly spoken of in the trade as "half-grades." Some cotton markets, notably New York, formerly recognized quarter grades also. These were found impracticable after several years of trial. On January 1, 1908, the New York Cotton Exchange adopted the gradings named above.

Any discoloration in the cotton is noted in the grade by using the words "tinged" and "stained"; for instance, "strict good middling tinged," "good ordinary tinged," or "low middling stained." Tinged cotton is only moderately discolored; stained cotton may range anywhere from a light yellow to a deep red or, as it is called in the trade, "foxy" color.

The basis grade in all markets is "middling" white cotton. This grade is the universal standard by which the quality of all other grades is measured. It is a fleecy cotton, very nearly white in color, and containing only a small amount of foreign matter. "Fair" cotton, the highest grade recognized, is a very bright, white, clean cotton. The other grades down to "ordinary" contain an increasing amount of foreign matter, and the lowest grades usually are somewhat dingy. Below "low ordinary" are some miscellaneous classes of cotton for which there are no recognized grades and which are of poor value.

Every cotton crop is more or less distinctive in character. Thus, one crop may be very bright and white, another may be of a creamy character, another dingy. On this account one often meets the expression that cotton is of "good

color," meaning that while it may not be strictly white it is not discolored by being tinged, spotted, or stained.

Method of grading in cotton-exchange towns.—Grading is a simple, crude process in the little local markets where the farmers sell. The buyer does hardly more, as has been stated, than pull out a sample from each bale, examine it, examine the bale itself whenever the lint shows through its wrappings to see that the cotton runs about the same, estimate the grade, and then offer his price. Frequently the buyer may be wrong in his grading by as much as two or three grades according to the standard of the expert grader of the big markets. In the big markets grading is done by one who makes this his sole business. He usually works under the authority of the city or the cotton exchange. The method followed is somewhat as follows: Samples are taken from the bales, and wrapped in paper with a blue lining because the blue gives cotton a good appearance. They are then taken to a testing room, opened, and allowed to stand for twenty-four hours. After this time the fibers are dried thoroughly—an important matter, for drying not only makes the cotton look better, but also displays more clearly any sand and dirt that may be mixed with it, for sand or dirt naturally falls into the paper when the lint is thoroughly dry. For the first reason, the sellers are glad to have the cotton dried; for the second reason, the buyers demand thorough drying. Next, in a good north light the samples are examined and graded, as many as three or four thousand in a forenoon by a single person. Proper notations are entered on each sample, which is then taken back to the bale from which it came. These notations of grade are marked on the bale, whereupon the cotton is ready for the buyers.

Value of the different grades.—The comparative value of the various grades varies with the supply and with the demand for specific grades by cotton manufacturers. To

illustrate the price variations, it may be stated that "low ordinary" cotton ranges from four to six cents less than "middling"; the other grades run accordingly.

English grades.—The greatest cotton market in the world is the Liverpool market in England. The same grades are employed there as in New York for American cottons, but it is said that the grading is done less closely than in this country. Liverpool receives large supplies of cotton from India. This is all classed in four grades: "fair," "good fair," "good," and "fine." Egyptian cotton is graded as "fair," "good," and "fair and good." Brazilian cotton has three grades: "middling fair," "fair," and "good fair."

MIDDLEMEN'S EXCHANGES OF COTTON

The local merchant or dealer who buys the cotton from the farmer ships it to the larger cotton markets and sells either to cotton spinning mills or to regular cotton merchants. The cotton cannot always be sent at once to the cotton mills; hence merchants generally have large storage houses where the cotton is collected and held until it can be shipped. They may sell either directly to the mills or to other cotton dealers or brokers. A large part of the American cotton is shipped abroad; hence the cotton merchants sometimes act themselves as exporters or else sell the cotton to regular exporters or to foreign buyers. Sometimes the merchants ship to Europe on the order of Continental cotton-buying houses or spinning mills; in other cases the foreign houses send buyers to this country who buy from the merchants or even directly from the local dealers and larger planters if they have a chance to see for themselves and judge the quality of the cotton.

The cotton exchange.—To facilitate the buying and selling of cotton, regular market places are established in most

of the large southern cities, and in certain other cities supplying the manufacturers. Buyers and sellers of cotton come together in these places, make their various offers and bids, and complete their transactions. This place of meeting, often a building especially fitted for cotton trading, is known as a cotton exchange. The work of the exchange is carefully governed by a set of rules laid down by an association of the dealers meeting there. These rules cover everything from how the business is to be conducted to how the cotton is to be graded. All the cotton merchants, many local dealers, all the exporters and cotton brokers, and even many cotton spinners belong to some cotton-exchange association, or sometimes to several. The membership gives one the right to come in and do his trading in the cotton-exchange building under the rules of the association. Spinners usually obtain their cotton through these exchanges, although a certain amount is purchased directly from planters or local dealers by the southern mills in the cotton belt.

Spot sales and future sales.—In the cotton exchanges two sorts of sales are made; the first is known as a "spot" sale, calling for delivery of the cotton at once, and the other as a "future," in which the cotton is to be delivered at some future time. Spot sales are familiar to all in every trade. Selling or buying for future delivery suggests that there is an element of speculation in cotton trading that needs to be explained.

Market price variations.—Anyone who will follow the market reports of cotton prices will presently note that the prices at which cotton is bought and sold vary considerably from time to time. In fact, cotton prices vary from day to day, even from hour to hour. This variation in price is due to many things: the variations in demand for cotton goods among the consumers of the world, the financial prosperity of the people, the conditions of crops, and the avail-

able supply of cotton. If the demand for cotton is strong and the supply small, the prices will go up; if the demand is weak and the supply ample, then prices will go down. During a year of hard times people buy less clothing than during prosperous times; hence we say that the demand falls off. If at the same time there happens to be a good cotton crop, farmers and cotton merchants will not be able to get so much for their product as when times are good. When the cotton crop is poor, the supply is diminished and the price rises, because people must pay more when there is not enough of the products demanded.

The markets show tendencies of supply and demand long before the people know anything about what is going on. For example, if cotton manufacturers and merchants should learn from the government reports or otherwise that the cotton boll weevil was destroying an unusually large amount of young cotton bolls in July, they would judge that the supply of cotton would be by that much diminished in November, and that the price would therefore go up at that time. Being good business men, they would not wait until November, but would immediately begin buying up the cheaper last year's cotton. This stimulated demand in July would at once result in an increased price; but November's price would be still higher.

Every hour of the day brings to the markets news from all over the world about cotton crops, cotton supply, and cotton demands. The effect of this news is shown at once in the price. An unimportant bit of news may change the price no more than a quarter of a cent a pound; tidings of war in India would make the price jump several cents.

Cotton speculation.—Everybody knows that prices will change. The difficulty lies in telling whether they will go up or down. Chance largely decides the matter. Keen foresight and experience give some men rather unusual

powers in predicting probable market variations. Unfortunately, plenty of people who lack these are ready to believe that they have the necessary knowledge and good fortune to buy cotton when it is low in price and hold it for a higher price. Cotton speculation thus comes into existence. If cotton goes up, the speculators who have bought win; if it goes down, they lose. Even the best of the cotton brokers make mistakes, but what they lose on some transactions they hope to make up on others.

Dealing in futures.—Cotton speculation often takes another form which is called "dealing in futures." A spinner sometimes fears that the price of raw cotton may go up, but he must go ahead and take orders from weavers for great amounts of yarn to be delivered at some future time in order to keep his plant busy. What price shall he put on this yarn? Can he make it low enough to insure his getting the order, and yet leave him a fair profit? If he figures the price of the yarn on the basis of the current cost for raw cotton, he will be protected, provided raw cotton does not increase in value. If it goes down he will make a larger profit; if it goes up, he will lose. What can he do to insure himself against loss? Most spinners who do not care to incur any risk of rising prices of raw cotton buy at current prices from a broker or merchant on the exchange the amount of cotton that they will need to fill their orders, *stipulating that this amount be delivered at some stated future time,* the time when they will need the cotton at the factory. The risk of loss because of rising prices is thus transferred from the spinner to the cotton broker. The spinner can now go ahead with a feeling of security, for he knows that whenever he wants it he will have his cotton from the broker at the specified price. Of course, if cotton prices should fall, not he but the broker would profit thereby. But most manufacturers feel that it is the best policy to keep out of speculating on cotton prices as

much as possible, and to depend upon manufacturing profits rather than upon market profits of raw cotton. It should be noted that the broker who sells the cotton to the spinner may not have any cotton on hand when the contract is made. The cotton may not even be in existence. It may be still on the plants in the fields hundreds of miles away, not ready to be picked for months. The broker simply agrees to supply the cotton at a given future date and at a certain price, hoping to be able either to find the cotton before that time, or to sell his contract to someone who can furnish the required amount of cotton on time.

Hedging.—Shortly after making the contract the broker may conclude that prices are going to rise and that he will lose on his deal. In this case he does what the spinner did; that is, he goes to the cotton exchange to find someone who will agree for as low a price as possible at the given future date to supply the cotton contracted for. If he finds such a seller, the risk that cotton may go up is thus transferred to this third party. In like manner one contract for cotton for future delivery may pass through a number of hands, each man buying or selling as his judgment and circumstances dictate. Covering a future sale by a future purchase, as carried on by the broker in the way described above, or as done by the spinner who bought from the broker to cover future sales, is known as "hedging." Wherever there is dealing in futures, there will inevitably be a certain amount of such hedging, for it allows the losses due to changing prices to be shifted by the spinners upon the brokers, and by the brokers among themselves, often in such a manner as to cause no great loss to any individual.

Cotton trading.—There is much of this buying and selling in cotton futures. Great quantities of cotton are contracted for in this way, practically all of which have no existence except on paper at the time the contracts are made. Most cotton brokers at the exchanges never see the material

that they buy and sell. Numerous contracts for future delivery of cotton are bought and sold back and forth so as to cancel each other before the time of delivery. Contracts in the possession of one man may be used simply as a means of paying a debt to another, and so on indefinitely, just as bank checks are passed from hand to hand, no cash passing until the final settlement.

Criticisms of dealing in futures.—Dealing in futures on the cotton exchanges has been condemned by many people as gambling. It certainly has much of the gambling element in it, and many abuses in the cotton trade have grown out of it. On the other hand there appear certain good results. For example, the cotton manufacturer gets rid of the risk from taking chances on the market when he is fixing prices on ordered goods. This permits him to give his whole time to the efficient management of his business. Both manufacturers and the public are by that much the gainers. Again, the dealing in futures has the effect of equalizing price variations, an undoubted benefit to the producer, who can then feel more certain about what he can get for his crop when it is ready for market. Buyers and dealers all along the line can handle the cotton on closer margins because of the smaller chance of price variations; hence the farmers get more for their product. On the whole, if the cotton exchanges are properly regulated, the benefits of cotton speculation outweigh its evils.

During the years 1908 and 1909, the United States Bureau of Corporations made a full investigation of the system of dealing in futures. In its report, published in three large volumes, judgment was given fairly and impartially, and while several recommendations were made for the regulation of dealing in futures, prohibition of such dealing was not advised. It is noteworthy that the principal cotton exchanges of the country, such as those at New York, New Orleans, and other large cities, have voluntarily complied

with these recommendations. Cotton trading is now upon a better basis than ever before.

In general, cotton marketing is fairly well organized. There are, no doubt, many things that could be bettered, but when one learns that it costs only about four-fifths of a cent a pound to get the cotton from the farm to the cotton exchanges, an amount covering not only transportation charges and handling but also all profits on the way, one must conclude that there is little waste in the marketing system. The entire expense of marketing cotton, covering all expenses and profits, from the American plantations to the cotton mills of Liverpool, is only about one and one-half cents a pound.

CHAPTER VI

COTTON MANUFACTURING

The manufacturing processes.—When the cotton finally arrives at the factory, it must undergo many long and interesting processes before it is finally turned into the forms suitable for consumers' use. The principal group processes were named in Chapter II: spinning, weaving or knitting, dyeing, and finishing, and finally the production of ready-to-wear goods. We shall now trace each of these processes in order.

Business organization of the manufacturing processes.—Generally each of these processes is conducted in a separate factory and under separate management. It is the exception to find one company owning all the factories necessary to turn out finished goods, although the number of such companies seems to be increasing. In most cases the spinning is done by one house, the weaving by another, the dyeing and finishing by a third, and the cutting up into ready-to-wear goods by still another. In most cases the goods change ownership with each move from plant to plant, although weavers and knitters frequently send goods to dyers and finishing houses to be colored and finished at so much a yard or a pound. Sometimes goods are handled by speculators or middlemen, known as converters, who buy the goods as they come from the loom and hire other factories to dye and finish them. There are in this country several cotton-manufacturing concerns that do their own spinning, weaving, and finishing, but none, so far as the writer knows, has

added cutting to its activities. Usually the woven and finished goods are turned over to some broker or jobber who in turn sells them to cutters-up or to the piece-goods trade; that is, the dry goods wholesalers and retailers the country over.

Purchase of cotton by spinners.—It has already been suggested that the spinners must get their cotton from exchange brokers or from merchants, and also that in order to produce yarns of a certain quality they may find it necessary or economical to mix two or more varieties of cotton. All the year round new cotton is coming into the big markets of the world. For example, American cottons begin to be available in November and December. Egyptian cottons come just a little later. India cottons are picked and shipped throughout the year, as are also those of Brazil, while Peruvian cottons arrive in February or March. Besides the new cottons, the warehouses contain cotton owned by farmers, merchants, or speculators, and held for increased prices or for filling previous contracts. From these various sources of supply of new and of old cotton, the spinner must get what he needs.

THE SPINNING PROCESS

The process of spinning is essentially nothing more than taking the loose, tangled fibers, drawing them into a smooth, uniform thread, and twisting the thread to give it strength. This process, formerly done by hand, is now accomplished by long rows of complicated and expensive machines in the spinning mill.

The cotton arrives at these mills in the bale. First the iron bands and the wrappings are removed that the bales may be broken into pieces. Then the cotton is loosened pretty thoroughly, after which any desired mixing of quali-

ties or varieties is performed. The cotton is then passed through machines that clean it, remove all impurities, and reduce every lump into a fine downy mass. Next it is carded, and if of fine quality and intended for the finest goods, it is also combed. From the carding and combing machines the cotton passes into drawing frames, machines that begin to draw the cotton out into a thread. It is then ready for the spinning machines where the final twisting of the yarn takes place. In an up-to-date plant human hands scarcely touch the cotton from the time it enters the bale breaker until it comes out from the spinning machines a finished yarn.

The steps in the process.—The first machine, known as the *bale breaker,* takes the big lumps of hard-packed cotton as it is found after the wrappings have been removed from the bale, and breaks them into smaller pieces, which pass into another machine called the *cotton opener,* there to be torn into still finer portions. In some mills the bales are broken up by hand, instead of by the machine bale breaker. The lumps made by hand-breaking are fed directly into the cotton openers.

In the Southern States, in sections where a considerable amount of loose cotton is hauled directly from the gin to the mill without baling, there is of course no use for the bale-breaking and cotton-opening machines. These machines simply undo what the baler or compress has done for the cotton fibers.

Mixing.—After the cotton bales have been broken into small pieces, the next step is *mixing.* This is generally done by conveying the cotton from the bale breakers and openers to bins, where a layer of one kind of cotton is covered by another, and so on until all the cotton of a certain batch or "mixing," as it is called, has been deposited in the right proportions. At the end of the operation the different varieties or classes of cotton lie in the same bin in horizontal

layers. When the mass is removed from the bin, it is taken out in vertical, or up-and-down, sections.

The picker.—From the mixing bin the cotton is conveyed by hand, or by machine in large modern plants, into a contrivance known as the *picker*. This pulls the cotton fibers into loose masses and delivers them in a flat sheet which looks like cotton batting, but which in cotton-mill language is called the *lap*.

The lap is immediately sent on to other machines known as the *intermediate picker* and *finisher picker*, each of which pulls the fibers into a still looser mass, and beats out sand, dust, and most of the other foreign matter likely to be found in a cotton bale. Each machine delivers the cotton in the form of a lap. In this form the cotton is much easier to handle and to feed into the next machine than loose bulk cotton would be. If the machines are not close together, the lap is wound into a roll like cotton batting, from which it is unwound when passed into the next machine.

The scutcher.—If there is considerable dirt in the cotton it is generally run through another series of machines known as *scutchers*. In the scutchers the cotton lap gets a great deal of beating and shaking which removes the foreign matter.

The cleaner the cotton is at the start, the less beating or scutching it needs. This is an important matter, for beating is sure to weaken a certain amount of the fiber, and the more beating it gets, the weaker will be the final product, the yarn.

Carding.—From the pickers or the scutchers, as the case may be, the cotton lap is transferred into the *carding machine*, the purpose of which is to remove all dirt, sticks, particles of leaves, and other impurities that were not removed by the pickers and scutchers. It disentangles the fibers still more, and lays them approximately parallel. Drawing out the lap into a thin filmy layer of cotton, usually

about forty inches wide, it then contracts this layer into a light, round cotton rope or ribbon about an inch in diameter. This rope is called the card *sliver*.

The carding machine or carding engine consists essentially of two surfaces both covered with great numbers of short, sharp teeth made of wire. These surfaces, called the cards, face each other with only a narrow space clear between the teeth. The cards move in such a way as to brush the cotton lint as it passes between them, combing out the fibers and catching all irregularities, such as dirt, parts of seeds, short fibers, and neps (little bunches of cotton fiber that have not been loosened). The lower card is in all modern machines a large revolving cylinder, while the upper card is shaped like a cover or roof over the upper part of the cylinder. A few years ago the upper card was a stationary device, but it has now been improved so that it moves also. This has been accomplished by fastening the carding surface to an endless belt or carrier, passing it around cylinders at the two ends and at the middle, and putting in devices to keep the lower side from sagging down upon the lower card. Thus both upper and lower cards revolve, but the cylinder turns at a much greater speed than does the top card, known as the *flats;* the cotton is therefore brushed and combed by the flats while being carried along on the teeth of the cylinder.

There are also in the carding engine other mechanical devices called respectively the *licker-in* and the *doffer*. The first draws the cotton lap into the cards; the second removes it therefrom. The cotton is removed from the doffer by a comb. The machinery having been so adjusted that the cotton travels faster in the cards than the rate at which the lap comes in, the stream or sheet of cotton lint becomes much thinner than the lap from the scutcher that enters the carding engine.

From the doffer the thin cotton lap is carried to what

is known as a *trumpet mouth* in which the entire lap is condensed into a round rope, three or four inches in diameter, called the card sliver. The sliver is immediately passed between a pair of calendar rollers which condense it to about the size of a broomstick. Thence it is conveyed to a little device that winds it spirally into a deep sheet-iron or tin can called the *sliver can.* When full, this can is carried to the *drawing machinery.* In case yarn of a very high count, or of a very fine size, is to be made, the sliver is taken to the combing machines to be combed before it is sent to the drawing frame. Practically all sea-island cotton, all yarn of sizes from 60's up, and certain fine yarns of lower counts are thus not only carded but combed also. In some cases, especially in producing yarn for medium-priced cotton underwear and warp for velvets and fancy woven fabrics, the cotton lint is run through the carding machine a second time instead of through a combing machine. The latter process has been found to be cheaper than combing.

Combing.—The combing machine simply does more perfectly what the carding machine starts to do in the way of cleaning the fibers, removing the neps and short fibers, and getting all the remaining fibers to lie smoothly and in parallel order. The usual combing method consists in taking several cans full of sliver to the machine and starting eight or ten, or even more, into the combing machine at once. These slivers are first converted into a smooth lap about nine inches wide and then are passed as a single stream or lap into the combing device. Here by means of rollers, nippers, and rows of metal teeth the fibers are thoroughly combed, and all short fibers, any dirt remaining, and other foreign matter are pushed aside as waste. There has been great improvement in cotton combing during recent years. The combing machines now utilize cotton fiber that is not more than seven-eighths of an inch long, and yet produce a sliver

that is almost as fine as that from the best cotton a dozen years ago.

Drawing.—Next, the slivers from the carding engine or from the combing machine are taken to the *drawing frame.* About six slivers are introduced together. The drawing frame takes these six and so draws them out that the resulting sliver is no larger than one of the card slivers. Drawing simply mixes the cotton, causes the fibers to arrange themselves in the best manner possible for the spinning that is to follow, and draws the combined six slivers out into the thickness of one. The drawing frame accomplishes this by means of several sets of rollers through which the slivers pass, each following pair of rollers having a higher rate of speed than the pair preceding. Requirements differ, but most cotton is run through drawing frames three times.

Next the cans full of sliver from the drawing frames are transferred to the *fly frames.* Here the cotton is drawn out into still smaller diameters and given the small amount of twist sufficient to allow the sliver to be drawn out further without breaking. For very coarse yarns the cotton passes through but two fly frames, the ones known as the *slubbing frame* and the *roving frame,* the product from the slubbing frame being called *slubbing* or *slub,* and the product from the roving frame *roving.* For medium yarns the cotton passes through three fly frames, *slubbing, intermediate* and *roving,* while for very fine yarns it is passed on to a *jack frame* to be drawn out still more. The cotton from the fly frames, now called roving, is wound on spools or bobbins and taken to the *spinning machines.*

Comparison of the mule and ring frames.—Spinning completes the drawing out of the cotton roving to the required size, and gives it the proper amount of twist. There are two kinds of spinning machines in use, one known as the *mule frame* and the other as the *ring frame.* The mule frame is the older machine invented in England, while the

ring frame is an American invention dating back to 1828. Each has certain advantages. For example, mule spinning produces a soft, oozy, elastic yarn that is very satisfactory for hosiery, underwear, and especially for woolen goods. The mule frame is more common in the woolen-spinning industry than in the cotton. Although it is much more complicated than the ring frame, takes up more space, requires more skillful operators, and does not run so fast as the ring frame, yet it is not so hard on the yarn, and it produces yarn of superior quality. The ring frame is not usually used for yarns running above 60's. The mule frame has three distinct and separate motions: first, the roving is drawn out; second, it is given the necessary twist; and third, the twisted yarn is wound on the spindle. The ring frame draws, twists, and winds, all at the same time. In both cases the yarn is wound on bobbins, cops, or tubes fastened on the spindle. This is the form in which it usually leaves the spinning mill. Sometimes, however, it is rewound on wooden spools by another machine called the *spooler*. Cotton yarn is quoted on the market as so much a pound for a certain size on cops, cones, or tubes, or in skeins. Often the yarns are combined, twisted double or triple—or two-ply or three-ply, as it is called. Special machines perform this operation.

YARN

Warp and weft yarns.—For purposes of making cloth two classes of yarn are spun, namely, a loose, slightly twisted yarn for the filling, not requiring much strength, and a hard twisted, strong yarn for the warp. Each class is sold as such by the spinners to weavers, and the weavers insist on getting the proper qualities in each to suit their purposes.

Long fiber for warp, short fiber for weft.—In cotton spinning it is profitable to use the longer cotton fibers for

the warp and the shorter fibers for the weft or filling. Some of the shortest varieties of cotton, such as Mobile, are used only for filling. The reason for this is that the warp must be spun harder and made stronger than the filling. The warp must undergo much handling and strain. It must be threaded through the heddles of the loom and stretched across the loom. Every move of the heddles up and down subjects it to new strains. Weft, on the other hand, is simply wound onto the bobbins that go into the weaving shuttles, and unwound into place between the warp threads. At no time need it be much stronger than to support its own weight; hence cotton can be spun into a much finer yarn or thread if it is to be used as weft or filling than if it is to be used as warp. Whenever warp and weft yarns of the same size are used, the warp is usually made from a longer fibered higher grade cotton than the weft. The shorter the fiber, the coarser the yarn must be made to have requisite strength, but weft, or filling, need not be so strong, and therefore not so coarse as warp yarn.

Cotton yarn sizes.—Cotton yarns used in the textile industry go by numbers, the number depending upon how many yards are required to make one pound. The unit is 840 yards; that is, yarn of size 1, which is taken as the unit or standard, runs 840 yards to the pound. Yarn size 10 would contain 8,400 yards to the pound, and yarn size 100 would contain 84,000 yards to the pound. The spun cotton is reeled into skeins, and these are tied together into hanks. A regular spinner's skein contains 120 yards, and since there are seven skeins in a hank, the hank contains 840 yards. So when a hank weighs one pound it is called size 1, or simply 1's. If the hank weighs half a pound, the size is 2's. If the hank weighs only an ounce, 1/16 of a pound, the size of the yarn is 16's, and so on, the numbers running up as high as 200's, which means 168,000 yards to the pound.

What a pound of cotton contains.—It is surprising to most students to learn for the first time that one pound of cotton fibers can be turned into so much yarn. When yarns of the proper sizes are used in making fabrics, one pound of cotton produces one and one-half yards of denim. It produces four yards of sheeting, four yards of bleached muslin, six yards of gingham, or seven yards of calico. It is even sufficient for ten yards of lawn, twenty-five handkerchiefs, or fifty-six spools of No. 40 sewing cotton. But one ceases to wonder at this when he learns that there are 140,000,000 fibers in a pound of upland cotton, and that if these were placed end to end, the line would extend a distance of over 2,200 miles.

Use of yarn numbers in handling cotton.—In speaking of the quality of a given kind of raw cotton, it is customary among manufacturers to state what size of yarn it will spin. For example, in speaking of India cotton, it might be stated that it will spin 12's. This means that its fiber is so short that it will not make a yarn finer than number 12, which runs 10,080 yards to the pound—a very coarse cotton yarn, such as is used in heavy sheeting, drills, and denims. Sea-island cotton will make a yarn as fine as 200's, and it has even been claimed that it has been drawn out as fine as 400's. It can well be imagined that cloth made of such fine yarn, even though closely woven, would be like gossamer, as light as air. Between those two extremes occur all the sizes of yarns used in ordinary fabrics.

The numbers spun from different varieties.—The following are some of the leading varieties of cotton with the average sizes of yarn made from them and some examples of uses made of the yarns. There is considerable variation in each kind of cotton and the table aims to present simply a general idea of the more frequent cotton qualities. Remember that the filling or weft yarns can be made from a fourth to a half finer than those for the warp.

Variety of Cotton	Average Length in Inches	Average Warp	Average Filling	Examples of Uses Made of Yarns
Sea-island	2	100	150	Sewing cotton, lace, imitation silk
Brown Egyptian	1½	80	120	Sewing cotton, foundation for silk, mercerized cottons, finest lawns, dimities
Peeler	1⅜	50	70	Fine lawns, silk mixtures, organdy
Orleans or Gulf	1¼	40	60	Lawns, fine ginghams
Allanseed	1¼	35	50	Ginghams, percales, nainsooks, shirtings
Upland	1⅛	30	45	Percales, calicoes, sateens, velveteens
Texas	1	25	35	Calicoes, fine sheeting, cheese cloth, galateas
Boweds	1	18	25	Sheetings, coarse calicoes, window Hollands
Mobile	⅞	8	20	Heavy sheetings, drills, tickings
India	⅞	..	12	Denims, ducks, tickings

Mixing cottons.—When manufacturers desire to produce a fabric that requires a certain size of yarn, they do not always buy merely the one kind of cotton, which, according to the table, will make that size. It is not always possible to get a full supply of any one of the kinds named; furthermore the list contains only a few of the many varieties that come to market, each with its own special qualities. There may be a crop failure in some one variety of cotton, or perhaps there is strong competition for this va-

riety, making the price too high for ordinary use. In order to produce yarn of a certain size a manufacturer usually buys part of his supply of cotton of better grade than necessary, and part of poorer. These he mixes in such proportions as will give just the grade desired. Sometimes as many as six or eight kinds of cotton are mixed in order to get the right quality in a yarn. Consequently, mixing cottons is a science in itself, and requisite not only in order to get a yarn of a certain size, but also to get the right smoothness, fineness, strength, and glossiness, or the right feeling to the sense of touch. Those who manufacture certain well-known brands of goods desire to maintain exactly the same qualities in those goods year after year. But all of the cottons naturally vary from year to year according to the season. The same variety will not have exactly the same qualities every year. To insure fixed qualities in his standard goods, the manufacturer employs blends or mixtures that will give the same result every time. The proportions of the various kinds of cottons are varied as may be necessary to preserve the same qualities in the mixture.

English cotton-mixing table.—The following table shows how cottons are usually mixed by English spinners in making first-class qualities of yarn. Only sizes of warp are given. Weft or filling can be a fourth or more finer from the same blends. Note that many varieties of India cotton are named. Practically all the India cotton is exported to England.

Under 12's—Bengal sind and cotton wastes
" 15's—One part Bengal, one part Smyrna, and one part Chinese
" 20's—One part Dharwar, one part Dhollerah or lower grades of American cotton
" 30's—Better grades of Indian with strong low classes of American
" 40's—Middling grades or Texas mixed with one-half as much Peruvian or Brazilian

Under 50's—Good, fair, brown Egyptian or higher grades of American cotton, mixed with not more than one-third Marahans, Santos, or Punams
" 60's—Fully good, fair, brown Egyptian
" 80's—Good brown Egyptian alone or mixed with Joannovich or very good Abassi
" 90's—Combed brown Egyptian mixed with Joannovich or Abassi
From 90's upward—combed sea-island

The American cotton spinner mixes according to the same principles, but uses a larger proportion of American varieties.

In general, most American cottons are made into yarns running from 32 to 36 for warp or twist and 36 to 40 for weft or filling. Egyptian cotton is used in preparing yarns running from 50 to 60 warp and from 42 to 62 weft, the poorer grades and shorter fibers being used in the weft.

Forms in which yarn is put up.—Yarns are delivered from the spinners to the weavers in eight different forms, as follows: (See illustration.)

A. In skeins or hanks.
B. Wound on wooden or metallic spools.
C. Wound on cops, the usual form in which the yarn is wound on the spindles.
D. Wound on paper tubes instead of cops.
E. Wound on double-headed bobbins, much like large spools in appearance.
F. Wound in the form of cheeses.
G. Wound in ball form.
H. Wound on the warp beams ready for the weaving processes.

THE WEAVING PROCESS

The steps in the process.—Preliminary to weaving is, of course, the determination of the kind of cloth to be made and the amount of yarn going into it. By arithmetical

THE VARIOUS FORMS IN WHICH YARNS ARE PLACED UPON THE MARKET.

computations, it is found how many warp threads will be required to make the cloth of the required width. This is spoken of as finding the required number of "ends." The filling or weft threads are called "picks."

Winding the warp.—When the number of ends needed has been computed, arrangements are made to have these *wound on the loom warp beams* in the necessary manner. The threads are distributed along the beam at equal distances and wound on very evenly and carefully, each at the same tension, for this even tension in all of the warp threads on the loom is highly desirable during the weaving.

Sizing.—After the warp is strong and smooth, the warp beams with the warp wound thereon are placed in the looms, and weaving is begun. But most warp needs further treatment before it is thus ready to be used in weaving, especially if it is a single-twist yarn and not very strong. It must first be sized, that is, given a coating of some stiffening substance that will give it strength, stiffness, and smoothness. Without this sizing it would be liable to break when subjected to the strain and friction of weaving. Sizing is composed of many different substances—in most cases, of some kind of starchy substance, such as wheat flour, cornstarch, potato starch, or sago flour. This substance is usually boiled in water, and a little tallow, paraffin, or other oily substance added to soften it. To this some preservative is added, such as chloride of zinc, cresol, or salicylic acid, to prevent souring, mildew, or other bacterial action or vegetable growth. The sizing applied to the warp has a purpose distinct from that used in finishing cloths. The latter will be described later.

The method of applying the sizing to the warp yarn is somewhat as follows: The warp beams holding the warp yarn are taken to the tank which contains the sizing. The tank has a roller in it with the lower side immersed. The ends of the warp from the warp beam are passed under this

roller, then out of the tank and over other rollers heated by steam, and thence upon the warp or weaver's beams. This process of unwinding the warp and immersing it in the sizing tank thoroughly saturates it with the sizing. Running it over the steam-heated rollers dries it, and when wound on a weaver's beam it is ready to go to the looms.

Preparation of loom.—The next step is the preparation of the loom. The beam with the sized warp on it is fixed into place at the back of the loom, and the ends of the warp are passed up through the harnesses and reed, each thread in its proper place. The ends are finally fastened to the taking-up roller at the front of the loom, whereupon the loom is ready for the weaving. The harnesses raise and lower the warp threads properly, the shuttle begins to fly back and forth between the warp threads as they are raised and lowered, leaving behind it a trail of warp from the shuttle bobbin, and the weaving of the cloth has begun. After each trip of the shuttle, the reed automatically strikes the weft thread into place, leaving the finished cloth closely woven. As fast as the cloth is woven the taking-up roller pulls it forward and winds it.

The machines and the laborers.—Throughout the processes that have been described in this section, every part of the work except moving the cotton from machine to machine, starting the machines, keeping them oiled and in repairs, and mending breaks and tears in the product, is done by machine. The simple attention that the machines need is given in most cases by men of no unusual skill, by women, and in some parts of the country by children. Competition and other conditions have brought the prices of the finished product down so low that the making of a profit above costs of production is a problem of efficiency in management. Many a mill makes no profits on certain contracts, and not a few lose money. There is constantly an effort to get cheaper labor; whence frequent difficulties result between

laborer and employer. The cotton worker's standard of living is gradually becoming lower, approaching the standard of the people in the same occupation in other countries. This not unnaturally makes American operatives restless. Nor can we believe that these difficulties are likely soon to end except in plants where the management is both humanitarian and businesslike.

Air conditioning in cotton mills.—Certain physical conditions seem necessary for successful cotton manufacturing, among others a moist atmosphere. Up to a few years ago, it occurred to no one to produce those conditions artificially; wherefore only the regions with a wet or moist climate were successful in putting out the best yarns. Lancashire in England, and eastern Massachusetts were two such regions. But now contrivances have been invented which supply the necessary moisture to the air of the cotton mills in proportions more certain than the Lancashire or Massachusetts climate could guarantee. These contrivances are called humidifiers, and the process of keeping the air moist is called air conditioning. In a dry air cotton becomes crinkly and brittle, and in the fly frames and spinning machines as well as in the looms the fibers break easily. But in a moist air the strength and behavior of the fiber are greatly improved. The air must not be too moist, however, for then other difficulties arise. The humidifier is so adjusted as continuously to keep a given proportion of water vapor in the air of the mill. The moment this proportion of water falls below standard, the humidifier sends out a thin spray of water vapor, stopping automatically as soon as conditions are rectified. The temperature of the mill rooms is also important. It has been found that at 75° Fahrenheit the cotton works up best.

Cotton waste and its use.—A cotton mill must utilize countless other mechanical and scientific devices. It must call nothing "waste." At every step there is a certain loss

of cotton fibers. This is especially true around the principal machines. This waste, known as "soft waste" until the fiber has left the spinning machines, and thereafter as "hard waste" (the particles of yarn or of cloth in the later processes), is carefully collected and used again in making cheaper yarns and goods. A good deal of the waste from the American cotton mills has in the past been exported, especially to Germany, where machines have been invented to take care of such matter and use it to better advantage than can our machines. It is used, for instance, in making cheap cotton goods for home trade among the German poor, and for export trade with China and other parts of the world where flimsy cottons are in demand. It has found a place mainly, however, as filling for cotton blankets, cotton flannels, cheap trouserings, towels, carpets, mats, sacks, lamp wicks, wadding, twine, etc. Lately American manufacturers have begun to install machines in the mills in this country to use the waste and to work it up at home. The utilization of cotton soft wastes will no doubt in time constitute an important part of our cotton industry.

Cloth inspection and repairing.—After the cloth has finally come off the looms, it must be inspected for any weak places, tears, or other imperfections. These are repaired as well as possible and the loose ends of warp and weft trimmed off, a process known as *burling*. Next the cloth is suitably marked if it is to be sent to bleacheries or dyeworks, and finally it is measured, rolled into bolts, and packed in paper. The bolts are then put into wooden boxes or cases. The cloth is now ready for the finishing processes.

CHAPTER VII

GEOGRAPHY OF THE COTTON TRADE

Reasons for the cotton trade.—In a previous chapter some mention was made of the cotton-growing areas of the world. The manufacturing of cotton is often carried on far from the plantations. Most cotton-producing nations also have cotton manufactures, but the entire product of the nation is seldom used up at home. The kind of cotton produced is in some cases not entirely suitable for complete manufactures; hence imports of other varieties and qualities may be necessary, while the unused surplus is sent elsewhere.

Extent of cotton trade.—By comparing a country's production of raw cotton with the consumption of its cotton factories we can get some idea of the vast world trade carried on in raw cotton. Absolutely accurate figures are unobtainable; the following table is, however, fairly dependable. It does not account for all of the cotton raised and manufactured, but what it does show will give an idea of the immensity of the trade in raw cotton.

It is clear from this table that a great deal of cotton is moved from places where it is produced to distant places where it is to be worked into yarns and fabrics. The discrepancies that occur in the table, such as a greater consumption by the factories than production and importation for the year, 1910, may be accounted for by possible stocks of raw cotton on hand from the previous year, for these are not included under production or imports. Again, much

PRODUCTION AND CONSUMPTION OF COTTON BY NATIONS FOR THE YEAR 1910, IN 500 LB. BALES

	Raw Cotton Produced	Total Imports	Factory Consumption
Total	19,171,000	....	19,013,000
United States	11,483,000	170,560	4,695,000
British India	3,508,000	11,723	1,650,000
Egypt	1,535,000	very little	very little
Russia	900,000	810,496	1,625,000
China	725,000	54,910	350,000
Brazil	360,000	10,775	370,000
Peru	128,000	none	very little
Mexico	135,000	31,291	140,000
Turkey	105,000	very little	very little
Persia	92,000	very little	very little
Great Britain	none	3,945,482	3,782,000
Germany	none	1,881,364	1,685,000
Japan	very little	1,320,853	1,060,000
France	none	1,070,530	960,000
Italy	none	769,881	790,000
Austria	none	749,056	749,000
Spain	none	320,142	315,000
Belgium	none	277,339	217,000
Canada	none	162,524	119,000
Switzerland	none	92,639	100,000
All other countries	200,000	not possible to give	125,000

of the surplus not consumed was either stored over into the year 1911 or reëxported to other countries.

Countries interested in the cotton trade.—Where does the cotton from the great cotton-producing countries go? By reference to the table it is clear that it must go to the great cotton-consuming or manufacturing nations that produce no raw cotton. The surplus of cotton from the United States, India, Egypt, China, Peru, Turkey, and Russia must go to Great Britain, Germany, Japan, France, Italy, Austria, etc. Some of the cotton going to England is reëxported from there to other nations.

Cotton-exporting markets.—Naturally certain cities in the cotton-producing countries have become important as cotton-exporting centers. In the United States, Galveston ranks highest in number of bales received and shipped, the amount running considerably over 2,000,000 bales per year. New Orleans and Savannah come next. New Orleans usually holds second place with a total yearly average of nearly 2,000,000 bales, but in 1910 the amount ran down to 1,315,000 bales and Savannah came into second place with 1,365,000 bales. The other important cities receiving and shipping cotton in the southern United States are: Norfolk, Virginia; Wilmington, North Carolina; Mobile, Alabama; Brunswick and Charleston, South Carolina. Considerable cotton is received overland at Baltimore, New York, Philadelphia, and even at Boston from the cotton states.

The chief exporting ports in the other cotton-producing countries are Bombay and Madras in India, Alexandria in Egypt, and Shanghai in China.

Cotton-importing markets.—Similarly, certain large cities have become prominent as the receiving centers for the great cotton-importing countries. No city in the world receives so much cotton as Liverpool. England's high rank as a cotton textile producer accounts for this, although a great deal of cotton received in Liverpool is reshipped in smaller quantities to various parts of Europe and elsewhere. American spinners frequently buy Egyptian or East Indian cotton in Liverpool. A few miles inland from Liverpool is another great cotton market, Manchester, the very heart of the cotton textiles manufacturing district of England. Cotton received here is used in the immediate vicinity.

Bremen and Hamburg are the chief cotton-receiving cities of Germany. Bremen gets mainly the American cottons, and Hamburg those from East India and Egypt. No small part of Hamburg's import, however, goes to Bremen before being sold to the manufacturer. Both Hamburg and

Bremen supply cotton mills in all parts of Germany, Austria, Switzerland, Netherlands, and Russia. Belgium also gets some cotton from Bremen, but more from Liverpool.

Havre is the great cotton-receiving port in France. Most of the cotton received comes directly from the United States, some from Liverpool, and a little from Hamburg. Dunkirk is the second greatest cotton-importing city in France. It receives American cottons mainly, whereas Marseilles in southern France receives considerable cotton from Egypt and India.

Reval is the chief cotton-importing city of Russia. Others of importance are St. Petersburg, Alexandrovo, and Odessa. Most of the cotton comes direct from the United States, but a good deal is transshipped from Liverpool, Bremen, and Hamburg. Persian and Egyptian cottons are received in considerable amounts at Odessa.

Barcelona is the chief cotton-receiving point in Spain. Rotterdam and Enscheide come first in Netherlands. Much of the cotton imported at these points comes directly from Germany and England. Gottenburg and Norrköping in Sweden, Christiania in Norway, Oporto in Portugal, Kobe and Yokohama in Japan are the chief cotton-receiving cities in the countries named.

In the United States, Boston ranks first as a cotton-importing city. This may be accounted for by its closeness to the cotton-manufacturing section of New England. Philadelphia and New York follow.

Liverpool, Bremen, Havre, New York, and Boston are the dominant cotton markets of the world. At each of these places there is a large association of business men whose sole purpose it is to promote commerce in raw cotton. The associations are known as cotton exchanges. In each of these cities is a large building used by the association for commercial trading. The working of the great exchanges is similar to that of the smaller and more general cotton

exchanges already described. The prices made at these great exchanges govern the cotton markets everywhere else. Since the greatest volume of cotton trading takes place at Liverpool, the Liverpool market is watched with greatest care not only by dealers in raw cotton, but also by cotton manufacturers, dealers in finished goods, and even by retail dry goods merchants. When cotton prices in Liverpool go up or down, cotton prices elsewhere are likely to follow their lead.

Why the greatest cotton market is not in the United States.—The main reason why the United States, the greatest cotton-producing country in the world, is not the world's chief cotton market, is that the cotton is shipped from the farms to places widely separated. The cotton mills of this country are scattered over an extraordinarily wide area; no one point, therefore, could serve profitably as a cotton market and jobbing center.

COTTON-MANUFACTURING CENTERS

We now come to a consideration of the geography of the manufacture of cotton. It is evident from the figures given in the table in the first part of this chapter that cotton manufacturing must be done in the countries where cotton is received and collected. The United States, England, Germany, British India, Russia, Japan, and France, in the order named, manufacture the most cotton at the present time.

Cotton manufacture in the United States.—In 1910 there were in the United States 1,324 establishments producing all kinds of cotton goods except hosiery and knit goods. There were in this same year 1,374 hosiery and knit goods plants (using wool and silk as well as cotton), making a total of 2,698 cotton-using factories in the country.

Although these plants are widely scattered, few states being without one or more, most of the establishments are located in three regions—New England, the Middle states, and the South. In a general way, and with many exceptions, New England manufactures the finer grades of cotton cloths, the Middle states manufacture knit goods, and the South produces the coarser grades of the staple cotton cloths.

Cotton Manufacture in New England.—New England is, as we have seen, the historic center of cotton production in this country. More than a hundred years ago the industry was fairly well established in Massachusetts and Rhode Island. Later it spread to Connecticut, New Hampshire and Maine. New England does not today use so much raw cotton as the South, but it produces more yardage, because it specializes upon the finer grades.

Some of the present chief cotton-manufacturing centers of New England are:

In Massachusetts:

Fall River—prints, twills, sateens, sheetings, cambric, muslins, shirtings, fine and fancy goods. Fall River had 104 cotton mills in 1912.

New Bedford—sheetings, muslins, lawns, sateens, prints, brown goods, fine goods.

Lowell—sheetings, drills, fancy dress and combed goods, duck, prints, shirtings, canton flannel, denims, chambrays, plaids, seersuckers.

Lawrence—sheetings, sateens, shirtings, dress goods, fancy prints, cottonades, denims.

Other Massachusetts towns manufacturing cotton goods of a similar nature are Adams, North Adams, Amesbury, Blackstone, Chicopee, Clinton, Holyoke, Salem, Taunton, Webster, Ware, West Salem, Whitinsville, and several others of less importance.

In Rhode Island:

Providence—sheetings, shirtings, sateens, ginghams, bleached goods, etc.
Pawtucket—sheetings, shirtings, cambrics, lawns, twills.
Lonsdale—bleached goods, silesias.
Manville—plain goods, ginghams.
Warren—sheetings, shirtings, twills, sateens.
Woonsocket—sheetings, shirtings, fancy goods.

In New Hampshire:

Manchester—ginghams, denims, tickings, sheetings, shirtings, drills, ducks.
Nashua—sheetings, shirtings, cotton flannel.
Other New Hampshire cotton-manufacturing towns are Dover, Newmarket, Somersworth, and some others.

In Connecticut:

The products are much the same as those produced in Massachusetts mills. The more important factory towns are: North Grosvenor, Dale, Danielson, Montville, Norwich, Taftsville, Waregan, and others.

In Maine:

Lewiston, Waterville, Biddeford, Augusta, Saco, Brunswick, Auburn, and Lisbon.

The region of densest concentration of cotton manufacturing is southeastern New England, within a thirty-mile radius of Providence, Rhode Island. This area includes parts of Massachusetts, Connecticut, and Rhode Island. Here is wrought about one-third of the cotton spinning done in the United States. This is also the oldest cotton-manu-

facturing region in the United States. Samuel Slater started the first power spinning machine at Pawtucket, Rhode Island, in 1791. By 1809 there were forty-one spinning mills within this territory, and this part of the country has ever since held first place in cotton spinning.

COTTON MANUFACTURE IN THE MIDDLE STATES.—The Middle Atlantic states, especially New York and Pennsylvania, produce preëminently the cotton knit goods. Of the 1,374 cotton knit goods manufacturing plants in this country in 1910, Pennsylvania had 464 and New York had 360. No other state had as many as a hundred plants. The Pennsylvania plants were not so large nor so productive as those of New York. New York produced $67,130,296 worth of knit goods; Pennsylvania, $49,657,506 worth. Together they produced three-quarters of all the knit goods in the country. Massachusetts came next in importance with a total of $14,736,025; Wisconsin followed with $7,843,389. It must be remembered, however, that the value here given is not for cotton alone, but for all textile materials used in knit goods.

KNIT GOODS CENTERS.—Knit goods include underwear, hosiery, sweaters, knit jackets, etc. The cities producing most of these goods are New York, Utica, Cohoes, Amsterdam, Brooklyn, Albany, Little Falls, Troy, Syracuse, Rome, Rochester, and Waterford, in New York State. In Pennsylvania the chief producing city is Philadelphia; then come Harrisburg, Honesdale, Pittsburgh, Pottsville, Allentown, Reading, Royersford, Schuylkill Haven, and many others. There are several plants in Baltimore, and others scattered throughout Massachusetts, Ohio, Illinois, Wisconsin, Missouri, and several other states.

New York, Philadelphia, and Baltimore are the chief knit goods markets in the country. New York ranks higher than either of the others, and here are most of the large cotton goods and knit goods commission houses of the country.

Cotton Manufacture in the South.—The South has made remarkable progress in cotton manufacture since the Civil War. It is told that in 1881 there was a cotton exposition in Atlanta in which the possibilities of cotton manufacture in the South were vividly advertised by the governor of Georgia, who appeared at the fair one evening dressed in a suit of cotton clothes manufactured upon the grounds from cotton which had been that day picked in a near-by cotton field, the whole process having been in sight of the visitors at the fair.

Progress of the South.—This gave the public the idea that the raw cotton need not be sent to Massachusetts or to England in order to have it made up into cloth. The South has since gone into cotton manufacturing on a big scale, locating mills mainly along rivers and streams at points where power was cheap.

The Piedmont region.—Some miles inland from the Atlantic Coast, the lowlands or plains rise abruptly into hilly ground and highlands. This upland district, called the Piedmont region, stretches backwards to the Appalachian Mountains and north and south from Alabama to the Potomac River, varying in width from about fifty to one hundred and fifty or two hundred miles. Every river that comes down from the Appalachian Mountains through these highlands has at some point a rapid current, generally at the beginning of the Atlantic plain. There is thus a regular line of waterfalls and rapids all along the Piedmont region, furnishing abundant water power. Large cities have been built all along this line, from Washington, D. C., to Tuscaloosa, Alabama—among them, Richmond, Lynchburg, and Danville in Virginia; Asheville, Burlington, Cedar Falls, Charlotte, Concord, East Durham, Greensboro, Kings Mountain, Roanoke Rapids, Spray, Salisbury, Winston-Salem, and Raleigh in North Carolina; Anderson, Chester, Columbia, Darlington, Greenville, Lockhart, Newberry, Ninety-Six,

Rock Hill, Selma, Spartanburg, and Union Warrenville in South Carolina; Atlanta, Augusta, Columbus, Griffin, Jefferson, Lindale, Hogansville, and Gainesville in Georgia; and Birmingham, Huntsville, and Tuscaloosa in Alabama.

In addition to the great cotton-manufacturing centers of the South just named, there are numerous others which, though of less importance, nevertheless produce in the aggregate a large amount of cotton goods. It has been stated that there are so many cotton factories all along this Piedmont region waterfall line that one can almost throw a stone from one mill to the next all the way from Alabama to Virginia. This is exaggeration, but it emphasizes the extent to which practically every stream that goes through the Piedmont region has been utilized.

Qualities of southern production.—While, in the main, the South produces the coarser grades of cotton cloths, yet there are exceptions to this, just as there are exceptions to New England's producing the finer grades. For example, great quantities of coarse cotton duck, denims, seersuckers, drills, and sheetings are made far up in Maine, while some mills in Georgia and South Carolina produce fancy weaves, cotton damasks, fine shirtings, sateens, and fine white goods. None the less these are exceptional cases. It is to be noted, however, that there has been a gradual increase in the manufacture of finer goods in the South, as there has likewise been a gradual change in New England in favor of producing only the finer grades.

Future of cotton manufacturing in the South.—It is hard to tell what the future will bring for these two sections of the country. It looks very much as if New England might some day have to fall behind the South, for the South has an advantage not only by being close to the cotton fields, but also by having cheap power and cheaper labor than that of the North. The New England states, however, still have the advantage in skilled labor, and in well-established and

widely known plants, and their power is not much more costly. Furthermore, for the present at least, New England is nearer dense cotton-using populations. Again, New England has the Boston and New York jobbing markets, a matter of high importance in the cotton textile business.

Cotton manufacture in England.—The cotton industry of England is located mainly in Lancashire, the business center being Manchester. The business is more concentrated in England than in other countries. South Lancashire is the spinning section and North Lancashire the weaving. Oldham, according to John Worrall's 1911 Directory, had 16,419,256 spindles and 17,272 looms in the mills lying in and around this town, and is, therefore, the greatest spinning center; next come Bolton, Manchester, Rochdale, Stockport, Preston, and Leigh. Burnley, with 98,923 looms besides 581,426 spindles, is the greatest weaving center. Others of note are Blackburn, Preston, Accrington, Darwen, Colne, Manchester, Chorley, Bolton, and Rochdale. The finest yarns, especially those for sewing thread, are spun around Bolton and Manchester, Oldham being the largest producer of weaving yarns. Preston and Chorley produce the finer and lighter woven fabrics; Blackburn, Darwen, and Accrington, shirtings, dhooties, and other goods much used in India; while Nelson and Colne make cloths from dyed yarn, and Bolton is distinguished for fine quiltings and fancy cotton dress goods. Burnley is the center of the great print-cloth manufacture. Nottingham, although not in Lancashire, is the center of the lace, net, curtain, and hosiery trade.

Cotton manufacture in Germany.—The first factory was established in Germany in the latter part of the eighteenth century and contained three small spinning mules. The development of the industry was slow until the unification of the German Empire in 1870. Then the number of mills was doubled by the taking over of Alsace-Lorraine. Soon

after came a setback, but the industry was again stimulated by the later higher tariffs, receiving special impetus about 1889.

There are three well-defined centers of cotton manufacturing in Germany—the Saxon, the Alsatian, and the Westphalian. The first section lies north of the mountains of Bohemia and contains some 3,000,000 spindles, the main factory towns being Chemnitz, Mittweida, Plauen, Plue, Werdau, and Crimmitschau. The second section lies in the extreme southeast of Germany, and contains some 4,000,000 spindles, the chief factory towns being Mulhausen, Augsburg, Gebweiler, Logelback, Kampten, Unterhausen, and Lorrach. The third section lies in the northwest corner of the Prussian Rhine and Westphalian provinces; it has some 2,500,000 spindles, located mostly in Gronau, Rheine, Bocholt, Epe, Rheydt, Muchen-Gladbach, and Mulfort.

Augsburg has the greatest number of spindles and looms and is the center for fine spinning; Mulhausen is more noted for fine weaving and printing; Chemnitz for knit goods; Plauen for embroidered lace; Crefeld for velvets; Muchen-Gladbach for colored goods; Barmen for braided work and ribbons; and Crimmitschau for vigogne yarn, etc. There is a little manufacture of machine-made lace at Leipzig and Dresden, and the latter place also manufactures artificial flowers.

Cotton manufacture in India.—Cotton manufacturing in India dates from 1854, when a Parsee merchant named Cowasji Davur built a small mill at Tardeo, near Bombay. The industry has been more or less under the control of the Bombay Parsees ever since. One half of the mills are on Bombay Island, and nearly three-fourths in the Bombay Presidency. The principal cotton-mill towns of India are Bombay, Ahmedabad, Calcutta, and Cawnpore; while Madras, Nagpur, Sholapore, Agra, Broach, and Delhi all have some factories. Ahmedabad, in Bombay Presidency,

is the second largest mill town, and is becoming the fine goods center. The average mill in India has 25,000 spindles, and the average weave mill about 500 looms. There are twenty-one mills that contain over 50,000 spindles or 1,000 looms each; the rest are decidedly smaller. The largest is the Jacob Sassoon mill at Parel, near Bombay, with its 92,840 spindles and 1,810 looms. The next largest number of spindles is in the Bengal mill at Calcutta, while the largest number of looms in a single mill is 2,015, in the Century Mill at Bombay. Two-thirds of the Indian spindles are of the ring spinning variety. Indian mills spin mainly 10's to 20's. The piece goods produced are mainly shirtings and long cloths, dhooties and chadars, T cloths, and sheetings. Production of other than plain woven gray goods is small.

Cotton manufacture in Russia.—The first power-driven cotton mill was established in Russia in 1840 by Ludwig Knoop, a young man who had learned the business at Manchester. Fostered by an exceedingly high tariff, the industry has increased until Russia now ranks fourth among the cotton-manufacturing nations. In 1911 there were 140 cotton mills with 8,448,818 spindles and 220,000 looms, furnishing work to 400,000 operatives. Cotton manufacturing is the most important manufacturing industry of modern Russia and employs over a third of the capital invested in all industrial establishments. The industry has more than doubled within twenty years.

There are three well-defined centers of cotton manufacturing in Russia: (1) The central, or Moscow district; (2) the Baltic, or Petrograd district; and (3) the western, or Polish district. The main cotton mill towns are Moscow, Vladimir, Piotrkov, Petrograd, Kostroma, Lodz, Tver, and Yaroslavl. Conditions are not favorable for the establishment of small mills; therefore the bulk of the industry is controlled by a few big firms. The Kren-

holm Manufacturing Co. at the small town of Narva near Petrograd has one of the largest cotton mills in the world; in 1910 it had 472,500 spindles and 3,672 looms, and employed some 12,000 operatives. This mill was built in 1856 and is operated by water power. Another mill at Yaroslavl, that of the Great Yaroslavl Manufacturing Co., has 261,886 spindles and 1,912 looms; one in Lodz, the Karl Sheibler Cotton Manufacturing Co., has 222,573 spindles and 4,848 looms. These are the three largest. Sewing thread is made mainly at Petrograd, knit goods at Girardof, and lace and curtains at Warsaw and Moscow. The annual production of the cotton goods industry in 1910 was given as 729,807,743 pounds of yarn and 615,576,261 yards of cloth. Some looms are made at Moscow, but the great bulk of the machinery is imported, mainly from England.

Cotton manufacture in Japan.—The cotton spinning and weaving industry in Japan has grown remarkably during the past few decades. With the constant encouragement and assistance of the government, this industry doubled the capital invested in cotton mills between 1892 and 1902, and has become one of the most important industries of the country.

The first power spinning mill in Japan was started in the year 1868 under the patronage of Prince Satsuma. Experts in spinning were engaged from England, and over 5,000 spindles and the other necessary machinery for a spinning mill were ordered from the same country. The growth of the industry was slow, however, until several years after the Restoration. In 1877 the government placed orders in England for machinery sufficient to start several small experimental spinning mills in different parts of the country. In 1882 the first cotton-spinning stock company was organized at Osaka with a mill equipment of 10,500 spindles. Since then the development has been rapid.

By 1890 there were 277,895 spindles in the country and in 1911 there were over 2,000,000.

Japan first attempted power weaving for the manufacture of cotton cloth in 1887. Up to the time of the Russo-Japanese War (1904-1905), the total number of power looms throughout the country did not exceed 5,000. The demand for cotton cloth for military purposes on the outbreak of the war with Russia, however, induced a number of cotton-spinning companies to install looms and engage in weaving. After the war came the demand for cotton goods in Manchuria, a market which had hitherto been almost entirely monopolized by American manufacturers.

The number of looms operating in the cotton factories in Japan, as reported by the Japanese Cotton Spinners' Association, was 15,515 in 1910 and 17,202 in 1911. Factory production of cotton fabrics in Japan, however, is comparatively unimportant when compared with the household industry. In small establishments and in the homes, cotton cloth is woven both on hand and power looms. These probably turn out more cloth than is woven in the factories. The fabrics produced are generally fourteen inches in width and put up in bolts of twelve yards. This quantity is sufficient for making an ordinary garment for men or women and is sold to the consumer by the bolt only. It is estimated that more than 100,000,000 bolts of this fourteen-inch cloth are produced yearly to supply the domestic market.

Cotton manufacture in France.—France, being the country nearest to England, was the first to adopt the processes invented by the English for the manufacture of cotton by machinery. Until Alsace with its 1,490,000 spindles and 29,175 looms was wrested from her in 1871, France was, next to England, the leading country in the manufacture of cotton. While the industry has never fully recovered from that blow, it has gradually developed, until it now con-

sumes about a million bales of cotton annually. France ranks fifth in the manufacture but third in the export of cotton goods.

There are three cotton-manufacturing sections in France: the northern, with Rouen as its center, making mainly coarse goods; the northeastern, with Lille as the center, making fine goods; and the eastern, with Epinal as the center, making medium to fine goods. There are, besides, a few mills scattered through the southern and central portions of the country. The principal spinning centers are Lille, Rouen, Roubaix, Epinal, Bolbeck, Barentin, and Laval, while the principal weaving centers are Rouen, Bolbeck, Tarare, Epinal, St. Die, Nancy, and Belfort. Lace making by machinery is carried on at Calais, Caudry, and St. Quentin. Some of the fine double yarns used in this industry are imported, but the bulk are now made in and around Lille, where the finest French yarns are spun. Tarare and Epinal are especially noted for the weaving and finishing of fine quality muslins; Roanne, for its colored cottons; Amiens, for its velvets; Cours for blankets; St. Chamond, for embroidery; St. Etienne, for ribbons; and Troyes, for hosiery. Cotton is largely used at Roubaix-Tourcoing in making mixed cotton and wool goods, at Lyons in making mixed cotton and silk goods, and at Vienne in the manufacture of shoddy goods.

Uses of waste cottons in Europe.—In the process of manufacture of cotton there is, as has already been observed, considerable waste, called soft waste before weaving and hard waste when in the form of cloth. This waste consists of light, short, poor, cotton fibers thrown out from the cleaning, lapping, carding, and combing machines, imperfect yarns from the spinning machinery, and the imperfect cloths, ends, and rags from the looms. This waste is nowadays worked up into the form of cheaper fabrics. The utilization of cotton waste has come to be a consider-

able business, especially in Europe, although there are beginnings even in this country. Germany and England lead the world in the production of cotton goods from mill wastes, and to these countries most of the waste from American mills is sent. Germany has been most successful in this field, and German inventors have made entire sets of machinery fitted solely for using wastes, from which they produce cotton blankets, wadding, batting, low-priced shirtings, and especially trouserings. The poorer classes of Germany look to this class of goods for their clothing needs. Belgium also uses considerable American cotton-mill waste of the poorest grades.

CHAPTER VIII

DISTRIBUTION AND PRICES OF COTTON GOODS

Most of the material in this chapter has been drawn from the Report of the United States Tariff Board of 1912 on the cotton schedule. This Board made a most exhaustive and careful survey of the conditions of the business in this country with respect to cotton and cotton goods. No better treatment of the subject has yet been printed.

Processes preliminary to distribution.—In most cases when cotton cloth leaves a textile mill it is not in the shape in which it ultimately reaches the consumer. Ginghams and other goods made of dyed yarns, as well as cloths which are retailed unbleached, such as certain kinds of duck, sheetings, etc., leave the mill ready to be placed on the market. The great bulk of cotton fabrics, however, reach the consumer either bleached or colored by one or more processes of finishing, such as printing, dyeing, mercerizing, etc. A number of textile mills have their own finishing departments in which the goods are bleached, dyed, or printed, and otherwise finished for the market. In most cases, however, the textile mills do not go beyond the process of weaving, leaving the finishing to be done in special finishing mills.

Most finishing mills finish goods on contract for converters or for textile mills which have their own selling agencies. Only a few large concerns combine under one control the business of finishing, converting, and distributing cotton goods.

The converter.—The converter is an important factor in the cotton goods trade in this country; it is he who takes the initiative and assumes the risk not only of placing finished goods on the market, but frequently also of ordering gray goods. His method of operation is as follows: Having studied the various styles of goods in demand in this and other countries, he selects a number of styles which he thinks are likely to prove popular, and places orders with textile mills for cloths of a given construction in the gray. The order is usually placed after a number of mills have been asked to submit bids on samples furnished them by the converter or have submitted samples made up for the converter according to specifications drawn up by him.

American mills generally require a minimum order of about 30,000 yards, including "tailings" (short lengths) and seconds, which must not exceed ten per cent. of the entire quantity contracted for. A reduction of five per cent. from the contract price is allowed for seconds. The contract usually calls for delivery of goods in installments extending over a period of from three to six months. Payment is made within ten days after each delivery on the contract.

Having placed his order for gray goods, the converter calls for bids from various finishing mills, and enters into an arrangement for the season with those offering the best terms and prices for the different finishes called for. As the goods are turned out by the textile mills, they are stored at the converter's risk either in the mill's warehouse or in the warehouses of the various finishing plants, subject to the converter's orders. From time to time, following the demand of the trade, the converter orders certain quantities of cloth held for his account to be finished. The minimum quantity finished at a time is usually 400 yards for bleached goods, 400 yards for dyed goods, and 7,500 yards for printed cloths. Deliveries are made in from two to six

weeks, and payment within thirty days after the delivery of the goods. During the rush season from December to February a longer period for delivery is required, which may extend to eight or ten weeks.

Both the gray goods mill and the finisher thus appear in the rôle of contractors, assuming no trade risks and doing business practically on a cash basis, while the converter, though not engaged directly in the process of production, assumes the initiative and the risks which in other lines of industry are generally borne by the manufacturer. It should be stated, however, that in staple lines, such as standard gray print cloths, sheetings, lawns, etc., mills frequently produce on their own initiative in order to keep their plants busy, and in such cases may stock up ahead of the "spot" demand.

The jobber.—Whether the goods are placed on the market by the converter or by the mill, they are, as a rule, handled in either case through the jobbing trade. Goods that are used by the cutting-up trade (manufacturers of shirts, shirtwaists, etc.) are, however, generally bought direct from the mill. It is also a growing practice among the large department stores to dispense with the jobber by buying direct from the mill. The jobber maintains a selling force not only at the place where he is doing business, but also by traveling over a large area soliciting trade among the retailers through whom the goods reach the ultimate consumer.

When sales are made.—The manufacturers and converters put out their lines and make their sales to the jobbers, beginning in May. Deliveries commence in November, continuing all through the winter and early spring, sometimes extending into April or May of the following year, the jobbers calling for their goods in accordance with the demands made upon them by the retailers. The jobbers make most of their sales to the retailers in September and Octo-

ber, but begin to deliver in January and continue into the summer, the retailers calling for the goods in accordance with their requirements. These terms of delivery do not apply to heavy cotton goods which are used principally in the winter, such as dometts, flannels, quilts, etc. These goods are generally ordered by the jobbers between October and December for delivery in June, and are purchased by retailers from March to May for delivery during August and September, most of the goods being sold to the consumer from August to January. This so-called fall trade is not to be compared in volume with the general spring and summer trade.

Location of finishers and distributors.—*Location of converting houses.*—The offices and warehouses of the converters and commissionmen dealing in cotton cloths are generally found in and near the cotton-manufacturing centers; the converters and commissionmen also maintain offices, usually in the great trade buying centers, as, for example, New York, Boston, Philadelphia, and Chicago.

Location of jobbing houses.—The jobbing of cotton goods is associated with the dry goods jobbing trade. The largest centers are New York, Chicago, and St. Louis. After these come Philadelphia, Baltimore, Boston, St. Paul, Kansas City, Denver, Atlanta, San Francisco, Cincinnati, Cleveland, Memphis, Dallas, Milwaukee, and a great number of other cities.

Retailing.—The retailing of cotton goods takes place in every city and village in the land. The amount sold varies according to the demand of the people. No figures are available showing the amount per capita purchased of each of the principal cotton manufactures, but it is known that over twenty-five pounds of raw cotton per capita are needed every year to supply America's present demand for cotton goods.

Expense of manufacturing, finishing, and distributing.

Manufacturing costs.—The costs of manufacturing cotton fabric include the costs of raw cotton, labor, power, mill expenses, depreciation in value of plant due to wear, repairs, insurance, taxes, and interest on capital invested in the mill. To the total of these expenses the manufacturer seeks to add something as profit.

Converters' expenses.—The converter also has his expenses, not the least of which is the risk which accompanies his undertaking when he puts in an order for patterns or styles that may not prove so popular as he supposes. His price includes the cost of the goods as they come from the manufacturer, plus the total cost of his labor, storage, and other expenses, plus such profit as he may be able to obtain in the markets or from the jobbers to whom he usually sells. As pointed out already, the converter's expenses may include charges for finishing processes which are true manufacturing costs, and for transportation to and from the finishing mills. The percentage added by the converter to the manufacturer's price will vary, then, according to the amount of work which remains to be done upon the cloth.

Jobbers' expenses.—The usual margin added by the jobber to his purchase is from ten to thirty per cent., most of the business being done on a fifteen to twenty per cent. basis. As will be seen from the table, however, instances are not uncommon of jobbers adding between thirty and forty per cent., while in a few instances the margin is less than ten per cent. These figures cover all the expense of marketing, so that there is here no indication of the net profit.

Costs of retailing.—The retailer, in his turn, adds to the jobber's price anywhere from one-third to two-thirds. As will be seen from the prices quoted in the table, retailers sometimes must be content with a smaller margin, anywhere from ten to twenty per cent., although the margin

occasionally may reach one hundred per cent and more. The large department stores are in a position to buy direct from the mill, and, in most instances, while somewhat reducing the retail price, combine the jobber's profit with their own. Where smaller additions to prices are made, they are usually coincident with frequent turnovers, so the annual profits may be as large as on cloths sold at a higher advance over the jobber's price but handled to a less extent. Of course the margin added by the retailer to the price he pays does not represent the net profit to the retailer, as out of this he must meet his selling expenses, which are greater for each yard of cloth than they are in the wholesale trade. As recently as fifteen years ago, the margin added by the retailers used to be much less, ranging from twenty-five to forty per cent, but the advent of the department store with its modern methods of marketing, expensive advertising, free delivery, and many other recent features, has considerably advanced the cost of retailing. The small retailer, so far as he can, must follow the standard set by the large department stores, and add such of these various features as are within his means.

Variation in prices.—Prices on given commodities are not maintained at the same level throughout the season. The retailer gets his regular prices until the month of May, when they begin to be reduced. In June, as the season wears on, they are cut considerably to prevent goods remaining on the shelves when the season is over. July and August constitute the "cleaning up" season, when white goods reach their lowest retail price level in the year.

Custom in retail prices.—The most important factor affecting the prices of cotton goods at every stage of distribution in the American market is the custom of charging "set" prices in the retail trade. The most common retail prices for different kinds of cotton cloths are 5, 7½, 8⅓, 10, 12½, 15, 19, 25, 29, 35, 39, 59, 65, and 75 cents a yard.

Deviations from these prices seldom occur, save in case of a special sale. It is only in the last few years that the 29 and 39 cent prices have been introduced. Little of the cotton goods is sold above 50 cents a yard, except in wide goods, such as cloths 40 inches wide and more, heavy upholstery goods, corduroys, velveteens, etc. Corresponding to these retail prices are the prices at which jobbers sell to retailers, and those at which they purchase from the manufacturers.

Range of customary prices.—The following table gives the prices which the retailer and jobber pay for cotton goods selling to the consumer at the customary retail prices. In addition to the average price charged by the jobber there is given his lowest and his highest price to retailers. There are given in the same manner, not only the average price, but also the highest and lowest figures obtained by the converters, or by the manufacturers who sell direct to jobbers.

PRICES OF COTTON CLOTHS IN CENTS PER YARD

Retail Prices	Jobbers' Prices			Manufacturers' Prices		
	Average	Low	High	Average	Low	High
5	4	3.25	4.5	3.75	2.65	4.1
7.5	5	4.25	6.5	4.75	4.25	6
10	7.5	7.5	8.5	6.25	6.25	7.5
12.5	8.5	8.5	10.5	7.75	6.25	7.5
15	10.5	9.5	11.5	9	8	10.25
19	12.5	12.5	13.5	10.5	10	11.5
25	16.5	15	18.5	13.5	11.5	16
29	19	16.5	22.5	16	14.5	20.4
35	25	19	26.5	20	14.5	22.5
50	35	32.5	37.5	27.5	27.5	33

Retailer's price.—To illustrate the connection between prices at the different stages of distribution, let us take a fabric retailing at 25 cents a yard. The usual price which

a retailer will pay for this cloth is 16.5 cents. If he has to encounter considerable competition and if he caters to a discriminating public, he may be obliged to get a higher grade of cloth for which he will have to pay 17.5 cents, and sometimes as much as 18.5 cents. On the other hand, if conditions are favorable to him, he will try to save on his purchase price by getting cloths at a lower price, paying as little as 15 cents and, in exceptional cases, 14.5 cents or less. Whether he pays 2 cents more than the customary 16.5-cent price, or 2 cents less, he will still continue to retail his cloth at the set price of 25 cents. Within certain limitations, therefore, competition between the retailers will take the form not of selling the same cloth at a lower price but of offering better goods at the same set price.

Jobber's Price.—This custom reacts upon the jobbing trade, and, in turn, upon the policy of the producer. The jobber knows that a fabric that can command a 25-cent retail price can be sold by him only within certain price limits. His price must not exceed, as a rule, 17.5 cents, and for exceptionally attractive cloths 18.5 cents, or the retailer will refuse to buy it; and it need not cost below 16.5 cents in ordinary times, since at that price it will yield the retailer his usual rate of profit. If the jobber has to encounter considerable competition, he will handle cloths which he can offer to the retailer at as low as 15 cents per yard. He need not go below that price unless he can make a considerable cut, say to 13.5 cents, in order to enable the retailer to sell at the next lower set price, namely 19 cents a yard.

Producer's price.—With these conditions facing him, the jobber has set limits for the price which he will pay to the producer. This will range from 11.5 to 16 cents as the extreme limits. Within these limits, the price will be affected by the same causes which regulate the jobber's price to the retailer; that is to say, by the quality of the

goods and the character of the trade catered to. The prevailing price paid by jobbers for goods of this grade is 13.5 cents.

Effects of the customary prices on production.—The existence of these set prices reacts not only upon the price policy but also upon the character of the production of cotton mills and converters. Knowing the price limits within which sales of commodities of certain grades can be effected, the mills adjust their production to suit these conditions. If a mill produces a cloth which it could sell at a profit for, say, 11 cents, it will, under favorable conditions, charge anywhere from 11.5 to 16 cents. The reason for this is that the producer knows that 11 cents is too high a price to the jobber to enable the cloth to retail at 19 cents. If there was no set retail price, as is largely the case in foreign countries, the cloth under these conditions would be sold by the mill at 11 cents and retailed at 20 cents. But knowing that the next retail price is 25 cents, the mill realizes that if it sold the cloth at 11 cents, it would merely enable the jobber or the retailer to make an extra profit, since no matter what price the jobber pays within the limits of 11.5 to 16 cents, the article will reach the consumer at 25 cents a yard. The producer will therefore charge a price nearer to 13.5 cents, or anywhere from that to 16 cents, if the cloth is of an especially attractive design meeting with little or no competition.

On the other hand, if the cost of production should rise, the producer cannot increase the price of his fabric beyond the limit set for the 25-cent cloth, as just explained. Should the cost of production change to an extent that would require an increase of price beyond this limit, the producer's price would either have to be increased beyond the limit, with the ultimate increase of the price to the consumer to 29 cents, or, more frequently, to 35 cents; or, if the jobber insisted that the cloth must be retailed at 25 cents, which

is more frequently the case, the only alternative would be to lower the quality of the cloth by reducing the number of threads to the inch or by effecting some other change that would not catch the attention of the average consumer. This practice is common, and a typical situation is described in the following extract from an article in the *Textile Manufacturer's Journal* of November 22, 1910, commenting upon the situation created by the high price of cotton which prevailed at that time:

> The sale of good-sized quantities of subcount prints emphasizes a feature in this division of the trade which may develop into sizable proportions. Demand for this character of merchandise seems to have had its inception and to have depended for its continuance upon the apparent need of goods at a price by the jobber. This status applies not only to prints but also to other classes of textiles. The development of such requests, however, has probably been greater in the case of the staple prints than in almost any other line. . . . Therefore, in order to produce business in volume, it was necessary either to reduce the price of existing qualities or to bring out new lines which by reason of their cheaper construction could be sold at cheaper prices. Of course, the former plan could not be pursued in view of the high price for raw cotton and printed cloth, and it was necessary to resort to the expedient of a lower cost of fabric.

What has been said with reference to the twenty-five-cent grades applies likewise to other grades. Each retail price given in the preceding table has corresponding jobber's and producer's prices which are ordinarily paid in the trade, but from which deviations occur both up and down within certain limits, according to the condition of the market. In the case of the retailer, competition at a given price-grade is confined to quality. In the case of the jobber and the producer, however, there is competition in price for a given grade within certain limits. As soon, however, as the price limit for the grade is reached, competition again takes the form of an adjustment of quality to a given price rather than of fluctuation in price.

To illustrate further the distribution of the retail price among the dealers and the producers, there follows a table

PRICES OF VARIOUS KINDS OF COTTON GOODS

Articles	Retail Price	Jobbers' Average Price	Manfrs.' Average Price	Average Production Cost
QUILTS	Each	Each	Each	Each
Crochet	$1.50	$1.00	$ .73	$ .67
Marseilles	3.00	2.00	1.40	1.18
Satin	3.00	2.00	1.30	1.00
UNDERWEAR	Suit	Doz.	Doz.	Doz.
Men's Balbriggan	.70	7.00	5.17	4.86
" "	1.00	8.50	6.81	5.37
" "	1.50	11.00	8.00	7.54
" "	2.00	15.00	12.22	10.21
Boys' "	.70	5.50	4.23	3.68
" "	1.00	8.00	6.42	4.53
Men's Fleece-lined	1.00	7.50	6.10	5.68
" " "	1.00	8.50	7.17	6.24
Ribbed	1.00	8.25	6.50	5.13
" "	2.00	13.50	10.50	7.10
Ladies' "	.15	1.50	1.30	1.31
" "	.25	2.10	1.73	1.41
" "	.50	4.00	3.25	2.15
" "	1.00	8.50	7.00	4.70
HOSIERY:	Pair	Doz. Pairs	Doz. Pairs	Doz. Pairs
Ladies'	.25	2.25	1.85	1.75
"	.35	3.00	2.40	2.20
"	.50	4.25	3.60	3.25
"	.75	7.85	6.50	5.65
"	1.00	8.50	7.00	6.75
Men's	.15	1.15	.95	.88
"	.25	2.00	1.85	1.60
"	.35	2.50	2.00	1.70
"	.50	4.80	4.00	2.84
Children's	.12½	1.05	.82½	.77
"	.15	1.50	1.00	.88
"	.25	2.15	1.80	1.75

showing the retail price of various made-up goods, the jobbers' prices to the retailer, and the manufacturers' prices to the jobbers. Another column is added showing average costs of production to the manufacturer; i. e., the cost of raw material, mill expense, labor, depreciation, interest on capital invested, and selling expense. The differences between the production costs and the manufacturers' selling prices show the manufacturers' profits.

The table does not show the margin of true profit that the retailer, the jobber, or the manufacturer receives. What is shown is simply the gross margin within which most concerns do business, some successfully, others not. Several factors affect the margin of pure profit, such, for example, as the annual turnover, the costs of doing business, the losses or leaks incident to the business, and so on.

Conditions affecting profits.—If a dealer can sell his goods rapidly and does not need to store large quantities for long times, thus not keeping his capital locked up, he is likely to get a pure profit at the margins fixed by the trade. Hence both jobbers and retailers buy their goods with the aim of selling them quickly, "from hand to mouth buying," as it is sometimes called. Goods that can be turned a dozen times a year, yielding a net profit of two cents on the dollar, make a better business than goods yielding four cents with only three or four turnovers per year. Goods that need not be carried in stock at all, those that can be ordered from the manufacturers and then immediately reconsigned to the retail merchant or the consumer, or goods that can be shipped direct from the manufacturer to the retailer or consumer, may be handled with advantage at a very small margin of pure profit on each sale; the gross margin may be less in most instances also. In such cases, expenses for handling, storage damage, risks from fire and other disaster are minimized or entirely eliminated.

The costs of doing business vary according to location,

the efficiency of the salespeople and of the system, the service requirements, and the amount of needful handling, storage, etc. Very efficient systems cut the expense down to a point that leaves a good profit margin, while other stores are not able to make any pure profit at all. Efficient salesmanship and economical system and service are the primary conditions of success in this matter.

The losses and leaks attendant upon a business have never been entirely eliminated; their amount, however, depends largely upon the system of management in the store. It may not be desirable to try to get rid of all such leaks, since the cost of such extra vigilance would perhaps more than counterbalance the losses prevented. Nevertheless, the main difference between a profit-making store and one that is running behind is often in the attention to such little details as breakage, spoilage, leakage, and slovenliness.

In manufacturing there are differences in the costs of production which seem almost unbelievable to outsiders. Differences in location, in power, labor, raw material, and machinery costs, in management, in secret processes, in the use of patented machines, in advertising and selling ability, and in many other respects explain why some manufacturers go into bankruptcy, while others, selling in the open market at the same prices, become opulent.

CHAPTER IX

LINEN

Ancient use of linen.—Linen is probably the textile that has been longest in use. Egypt and China used it thousands of years ago. It was the common textile of the people of Bible times, and was fashionable during the Middle Ages. "Purple and fine linen" represented regal splendor among the ancient orientals. In the Middle Ages linen underwear was thought to be too magnificent save for kings. Wonderful examples of early hand-wrought laces, embroideries, and tapestries in linen hundreds of years old are still to be found in the great museums of Europe.

Source of Linen.—Linen, a fiber obtained from the flax plant, is for the most part produced in central and northern Russia, Belgium, Holland, Ireland, France, Egypt, and northern Italy. Russia produces the most; Belgium, the best. Small amounts are produced in Canada and in Michigan, Minnesota, and Oregon. Large quantities of flax are raised only for the seed in other parts of the world, such as the Dakotas, Minnesota, northwestern Canada, India, Argentine, and southern Russia, but no means has yet been discovered for the utilization of both seed and fiber from the same flax, so as to get excellent results from both. If fiber is desired, the plants must be harvested before the seed is fully ripe; if seed is wished the plants must be allowed to grow until the fiber is too coarse, harsh, and woody for fine linens. The straw that comes from the flax in the Northwest is utilized in making very satisfactory

binding twine and rope. No doubt it could be used also for coarse fabrics or bagging.

Necessary factors of production.—Linen is a highly serviceable fiber, but the amount of hand labor required for its production is so great and the expenses so high that it is produced only where special advantages are offered in the way of cheap labor, special qualities of flax-producing soils, or unusual facilities for removing the fibers from the stalks. These advantages in some measure exist in each of the above-named countries and states. The growing of flaxseed has been found profitable because of the high prices paid for the seed by manufacturers of linseed oil, as oil especially useful in making paints and varnishes. None other has yet been discovered which better combines with paint pigments or with varnish gums, or which dries so well after applying. It has therefore no competing imitations or adulterants, and no substitute is practicable save possibly corn oil. Linseed oil is utilized to the practical exclusion of other oils in the manufacture of linoleum, oilcloth, oilsilk, patent and enameled leather, and printers' ink. It is also used for the manufacture of waterproof fabrics not made of rubber, for enameling wood-pulp buttons, for making opaque window shades, for a few medicinal purposes, for the making of soap (especially valuable for washing woodwork), and for various minor purposes.

The oil is pressed out of the seed in heavy presses like those used for the cottonseed oil. The cake remaining after pressing is a valuable stock food.

Character of the flax fiber.—The flax fiber is a slender, straight, tube-like thread of from twelve to thirty-six inches long, averaging about twenty inches. The fiber is found in a thin layer running up and down the stalk of the plant immediately under the bark. It is considerably stronger than that of cotton, but is more easily injured by bleaching and chemicals. The linen fiber, like that of cotton, is com-

Drying flax straw before removing seed.

A field of flax.

posed of almost pure cellulose. Hence like cotton it is attacked and burned up when exposed to acids.

Linen fibers range from white to bluish gray in color. The best flax in the world, that grown in or near the city of Courtrai in Belgium, is cream-colored. The coloring of the fiber, however, is probably due rather to the methods of treatment after it is gathered than to the variety of the plant or of the soil upon which it grew.

Flax growing.—The flax intended for linen is grown in the following manner: In northern climates it is sowed in the spring on ground prepared as for wheat or rye, a good deep, well-plowed soil being requisite. No particular care is then needed until harvesting, which comes in the latter part of July or in August. The plants, pulled up, roots and all, by hand, are tied in bundles and left to dry in shocks in the field.

Why flax must be pulled.—The pulling of linen flax by hand, instead of cutting it with a reaper or mower as in the case of farm grains, is necessary because:

1. Pulling the plants permits the full length of the fibers to be saved, whereas if the plants were cut off some inches from the ground, a usable part of every fiber would be cut off.

2. The flax fiber in the plant tapers to a point at both the upper and the lower ends. Cutting the plant would remove this lower taper, leaving a blunt end, which would prevent the fiber from being used in fine threads or fabrics.

3. Furthermore, the flax straw cures better and more evenly when the entire stalk is intact. No stubble is left in the ground and the flax shocks are not kept wet at the base by the ground water which comes out freely from the stubble of cut flax. The curing or drying of the flax is therefore facilitated.

Flax threshing or "rippling."—After the flax is properly dried, it is threshed. The bundles of flax, instead of

being fed into a machine like wheat bundles, are simply held up against revolving cylinders that beat off the seed heads; whereupon the bundles are withdrawn and thrown back into a pile. The older hand method, one still common in some parts of the world, is to draw the flax bundles across rakes or boards filled with spikes just far enough apart to let the flax stalks through but too close to let the flax heads follow. In this way the heads containing the seeds are pulled off, a process called "rippling."

Retting.—Next the flax is bound in convenient bundles, in preparation for "retting." Retting breaks down the solid contents of the flax stalks, starting fermentation and rotting. In fact the word to *ret* comes from, and means the same as, to *rot*. This process, when successful, causes the solid matter to fall away readily and easily from the fibers; the color of the fibers is then good, and the strength and luster of each fiber unimpaired. However, it is easy to over-ret the flax; hence the process needs careful watching, for over-retting dulls the luster while under-retting leaves some green color in the fiber.

Retting is a bacteriological process. The plant structure is attacked by a certain germ, much as a mass of dough is acted upon by yeast bacteria. Flax when retting must be watched as carefully as rising bread-dough; otherwise it will go too far or else stop too soon. This process is performed either in October and November or during the following spring and summer. There are at least four well-developed methods: dew retting, as practiced in Russia; pool retting, a common method in Ireland and also in Russia; running-water retting, the method employed in the celebrated Courtrai district in Belgium on the River Lys; and chemical retting.

Dew retting.—Dew retting consists in spreading the flax plants over grassy ground and letting them remain thus for from two weeks to four weeks. In that time decay sets in,

the hard parts of the stalks give way, and the fibers may easily be taken out.

Pool retting.—Pool retting is similar in principle to dew retting except that the process is considerably shortened by immersing the bundles of flax in pools of standing water, retting pools, or bogs. Ten days is usually sufficient to complete the process by this method.

Retting in running water.—Retting in running water, the method used in the Courtrai district, is similar to the pool retting method, except that the flax bundles are immersed and tied down in the running water of the streams or rivers.

Chemical retting.—Chemical retting has been tried at various times. Special apparatus has been built, patents obtained, and success promised, but as yet no chemical method has proved sufficiently valuable to lead large numbers of flax growers to invest in the machines required by the process.

Effects of retting.—The quality of the flax and its color are in great measure dependent upon the retting. Dew retting is rather uneven in its effects; hence the linen fiber from this process is usually the poorest in appearance although frequently the strongest in wear. Pool retting usually yields a dull gray or steel-gray product. Stream retting, as practiced on the River Lys in Belgium, is most successful, but it seems that in no other stream in the world can the same results be obtained. Chemists have analyzed the water of the Lys to see if they could discover the secret of its value, but so far they have been unable to find the particular quality involved.

The properties of Belgian waters for retting are so well known that flax is sent thither from France, Holland, and even from South America. From shore to shore the River Lys is crowded for many miles with weighted frames holding flax bundles under water.

Breaking.—After the retting is completed, the bundles

are removed from the water or are raked up from the ground, and then thoroughly dried. The flax stalks are then run through a machine called a "breaker." Here the rotted wooden matter in the stalks is thoroughly broken up and crumbled, by which means the fibers are gradually loosened and set free.

Scutching.—The breaking is followed by scutching; this is done by a machine which even more thoroughly beats the broken wood and pulp portions out of the fibers, leaving them fairly free from impurities.

Hackling.—The fiber is now ready for hackling or combing. This process is still usually done by hand, although machines have been invented for the purpose. This simple process consists in taking a handful of scutched fibers, throwing them over a fine-toothed iron comb, and drawing them through several times. Sometimes several sizes of combs are used, beginning with coarse and ending with fine teeth. In this process all impurities, loose fibers, short fibers, uneven fibers, and so on, are combed out. The residue is fine linen fiber ready to be spun into linen yarn or thread. The combings are called "tow." The fibers to be spun are generally classified according to length and color, and then laid aside in orderly piles so that they may not become tangled. Hackling demands much skill. An inexperienced person would be likely to make two serious mistakes; he would fail to remove all of the impurities, and he would waste much of the good fiber.

Large amount of labor required.—Throughout the process just described, from the gathering of the plants at harvest time to the final combing or hackling, hand labor is continually required, and care is necessary at every stage to preserve the best quality. Labor that while cheap is yet experienced is absolutely essential to the production of excellent linen fabrics. It has been estimated that it costs about $375 to work up $500 worth of flax from the straw

stage into yarn. It takes about \$375 more to transform this yarn into brown linen, and about \$250 more for bleaching. That is to say, \$500 worth of raw flax makes about \$1,500 worth of linen, most of this addition in value being the cost of labor.

Spinning.—The spinning of linen is much like that of cotton and wool. The fibers are run through spreading machines that divide the bunches of fibers evenly, and then into drawing frames much like those used for cotton fiber, and finally into the spinning frames. Fine threads must be spun wet, and the temperature of the spinning rooms must be kept at about 120 degrees Fahrenheit to prevent breakage and to get even yarns. Large or coarse sizes of yarn may be spun dry.

Qualities of linen yarn.—Linen yarn and the fabrics into which it is made are characterized by a high degree of smoothness, freshness, strength, and the quality of improving in appearance with laundering and wear. The color varies. That which is whitest is not by any means the strongest, but good fiber is always lustrous. Linen is not so elastic or pliable as cotton. It is rather leathery in feeling.

Linen finishing.—Linen is finished in various ways, just as is cotton. These finishes will be considered in a separate chapter. Linen does not bleach as readily nor does it dye as easily as cotton. Bleaches, unless very carefully applied, are likely to injure linen. On this account several grades of bleaching such as "full," "three-quarter," "half," and "quarter bleaches" are common. The whitest linen, that is, the full-bleached, is likely to be the weakest.

Irish linen.—Irish linen is the best-known and the most valuable in American markets. A good deal of the flax is raised elsewhere, but is manufactured in Ireland. Belfast, the center of Irish linen manufacture, imports fiber in considerable quantities, especially from Courtrai and other

parts of the European continent. The Irish linen workers bleach linens with the least injury to the fiber. This is perhaps due in part to the favorable climate and to the slower methods of bleaching employed.

European linens.—French, German, and Scotch linens rank next to the Irish. French linens are the finest and whitest, but are also the most fragile and hardest to keep in good, clean condition. Scotch linens are generally very good medium qualities. German linens range from very good to very poor, but average fairly good. Austria also produces a little of the linen that finds its way to America.

Adulteration of linen.—Linen is now often so adulterated with cotton in "union goods" that the substitutions or adulterations are hard to detect until the material has seen service. Even a great linen-manufacturing center like Belfast imports every year large quantities of cotton fiber and yarn. These cottons are worked up into the linen textile goods to the ultimate damage of the fabric. The methods of detecting these adulterations will be described later.

Uses of linen.—Linen is now used in the production of sewing thread, shoe thread, book-binder's thread, fish lines, seine twine, better grades of wrapping twine, handkerchiefs, toweling, table linen, linen damasks, dress goods, knit underwear, and, to a limited extent, collars, cuffs, and shirt bosoms. The linen collar, like the linen shirt, is passing out of existence. Bed linen that is really linen is not frequently found among the masses. Fine cotton has taken the place of linen in uncounted instances. A hundred years ago linen fabrics were made in greater yardage than all other fabrics together. Seventy years ago linen still led although it did not then make up more than half of all textiles. Now linen occupies third place, and it seems probable that it is destined to continue in this position unless some means can be invented to cheapen the costs of production. Such processes have been announced from time to

time, but so far they have affected neither the market supplies nor the prices of linens. When cheap cotton was made possible by the invention of the cotton gin, linen had to yield its position.

Few changes in fashions in linens.—Linen is a fabric which in its present uses does not change in fashion very frequently. For example, certain designs have for years been standard in table linen, among them the snowdrop, the shamrock, the maidenhair fern, the rose, stripes, checks, and polka dots. Hems and hemstitching constitute the usual means of finishing at the edges. Lace edges, once common, have practically passed out. Certain fashions, such as hand hemstitching, drawn work, hand weaving, and so on, are to be noted; yet all of these are so cleverly imitated by machinery that the difference can hardly be discovered. Except for the quaint distinction that associates itself with hand-wrought goods, the machine-finished linens are in every way equal to the hand-finished.

In towels there has been a gradual reduction in size from what was once considered standard. Now the usual towel size for family use is about 24 inches by 42 inches; towels 22 by 40 inches are increasing in use. The old-time towel was about 27 by 45 inches. Damask is a form of linen weave that has practically passed out for towel use. Huckaback and bird's-eye now lead.

In linen dress goods, fashion leads as strongly as in almost any other textile, although the range of possible variations seems narrower.

Linen mesh underwear is becoming popular, being porous, well ventilated, and reputed to be hygienic.

CHAPTER X

THE CLASSES OF WOOL

Character of the wool fiber.—Many animals have a hairy covering that may be used by man for textile purposes. The sheep is the most important in this respect. Wool, the hair of the sheep, differs from ordinary hair in at least two ways. First, wool is wavy or kinky, having from two to thirty "waves" or "kinks" to the inch, whereas common hair is straight or only very slightly wavy. Second, wool is covered with scales, from 1,100 to 5,000 to the inch; hair has few such scales.

Both the waviness and the scales give the wool a special textile value that other animal hairs do not possess. The waviness enables the wool fibers to be spun easily into fine elastic yarns. The scales cause wool to mat, rendering it possible to make wool cloth very compact, and even to make a felt fabric without weaving. Nevertheless, wools from different breeds of sheep vary greatly in these characteristics. Some wools are much like ordinary hair, and some hair is like wool. It is hard to draw the line between the two; in fact the same animal may have both ordinary hair and wool.

FACTORS DETERMINING THE QUALITY OF WOOL

The quality of wool usable for textile purposes depends upon the variety of sheep from which the wool comes, the nature of the pasturage for the sheep, the climatic condi-

tions, differences in seasons, the health of the sheep, and their cleanliness.

Varieties of sheep.—There are many varieties of sheep, to which, by means of interbreeding, new varieties are being continually added. Most varieties, however, go back to only a few classes. Some say that there are really only three great families; others insist that there are more.

WILD SHEEP.—It is probable that the various kinds of wild sheep found in many parts of the world originated from some common kind, but changed in appearance and characteristics because of the differences in climate, food, and surroundings in the various countries into which they happened to wander. These wild sheep may now be found in the Rocky Mountains, Africa, South America, India, Thibet, Java, and other lands.

TAME SHEEP.—Among the domesticated varieties of sheep the classification is fundamental, that based upon the use made of the sheep. One large class is known as the mutton sheep, because of the excellent food value of the flesh. The other class is known simply as the wool sheep. It generally is the case that mutton sheep have inferior wool, and that wool sheep are not particularly good food. A third class has been bred by crossing the two classes; these crossbreeds are useful both for mutton and wool production.

The principal mutton varieties of sheep are the *downs,* among which are the Southdowns, the Suffolks, the Hampshires, the Oxford Downs, and the Shropshires. The wool varieties include the *merinos,* of which there are several special varieties in the different parts of the world, such as the Spanish merino (the original of all merinos), the Saxony Electoral merino, and the French merino known as the Rambouillet. In addition to the merinos there are other varieties of wool sheep known as the *long-wools.* Under this classification one may include the Leicesters, the Lin-

colns, the Cotswolds, the Romney Marshes or Kent breeds, the Devons, the Wensleydales, etc. On the principle already mentioned, the Southdowns, Hampshires, and Shropshires, while excellent for food, have only short, rather poor wool; the merinos, on the other hand, have the finest wool in the world.

General characteristics of merinos.—The merino sheep is the best known and most widely distributed breed, and is often crossed with the English or native breeds. It is a comparatively small sheep, well covered with dense, crimpy wool. The length of the fiber or *staple,* as wool producers call it, varies with the type, but is usually less than four and more than two inches. The fiber is fine—sometimes, in the finest merino, as small as .0005 inch in diameter—and grows more densely than on any other variety. Coarse wool sheep have from 5,000 to 6,000 fibers to the square inch, whereas the merinos have from 40,000 to 48,000. The merino wool fiber has, furthermore, more scales on its surface than any other variety. Its fineness and the great number of scales on each fiber fit merino wool particularly for production of the finest fabrics. The merino sheep is very hardy, is easy to take care of in large flocks, and thrives under rather hard natural conditions; hence it is a favorite wherever the environment seems forbidding.

Variations in the merino sheep.—The merino, originally from Spain, has gone through numerous changes in the various countries to which it has been transferred. In 1765 it was taken into Saxony; here it developed into the Saxony merino, the finest of all fine-wooled sheep, which at one time was the main source of raw material for the finest broadcloths of England. The Saxon merino was also once popular in the United States, but is now seldom found there.

Merino in France.—In 1786 the merino was taken from Spain into France. Under the patronage of the govern-

ment it developed a type now known as the Rambouillet. A few years ago this breed was introduced from France into the United States and speedily became popular, especially in Ohio, Pennsylvania, West Virginia, and on the western ranges.

Merino in the United States.—The first merino sheep were introduced into this country from Spain about 1801. It is interesting to note that the first merino ram, costing over a thousand dollars, was presented to a Massachusetts sheep farmer by a Boston merchant. Since the farmer knew nothing about the special value of the ram, he shortly afterwards killed it for food. Learning a little later of his mistake, he immediately paid another thousand to have another ram imported. By 1804 there was established at least one merino-breeding farm in America, in Connecticut.

In 1809 and 1810, the American consul in Lisbon arranged to have several thousand merino sheep sent over to this country. From this time dates the beginning of extensive merino production in America.

One variety developed from these original merino sheep is now known as the Delaines, a sheep of fair mutton qualities and one that produces fine wool. The length of the fiber or staple averages about two and one-half inches. Great flocks of the Delaines are now found in the eastern and middle western states.

Vermont was at one time one of the world's chief breeding centers for fine merinos. From Vermont merino sheep were sent to Australia, New Zealand, and to several countries in South America, but particularly to Argentina; whereupon Vermont began to lose her preëminence in sheep breeding. Now there are almost as many dogs as sheep in the state, a fact that helps to explain why sheep raising is going backwards. Besides, Vermont, as well as the other New England states, is now raising sheep for mutton pur-

poses rather than for wool; hence the failure to keep up the pure-bred merino flocks.

Present merino wool production.—Merino production in the United States is now carried on in Ohio, Pennsylvania, and on the Western ranches, particularly in New Mexico, California, Washington, and Arizona. In view of the fact that formerly many more merinos were raised throughout the eastern and middle western part of the country than is the case today, and since frequently little care has been exercised in breeding, it is likely that some merino blood exists in a large number of the native sheep throughout the country. However, in mixing with the long wools and mutton breeds, the merino characteristics have generally been lost. The pure merino is no longer considered profitable in the more thickly populated parts of the country. In these parts farmers want sheep that will fatten rapidly so that they may be sold for mutton; hence the crossbred or the mutton type is generally favored.

Merino in South Africa.—South Africa had a woolless wild sheep when it was first settled by white people. Spanish merino rams were imported as early as 1680 and crossed with the native sheep. Wool production and exportation began in 1716. In 1775 a large number of merino sheep were imported from Spain, and from that time on South Africa has produced merino wool. This wool is noticeably uneven in quality, but that known in the London wool market as "Cape Snow White" is as good as the best wool in the world.

Merino in Australia.—Australia imported merino sheep from South Africa, from England, and from the United States; also indirectly through Tasmania from Saxony. Australia was already well established in sheep raising before 1830. Other countries, such as South America and New Zealand, have swung away from the raising of merinos to the mutton or crossbred types, but Australia has clung

Special Australian stud ewes.

Sheep shearing by machinery.

rather consistently to the merino. Between 1845 and 1854 a large number of Rambouillet rams were introduced from France and crossed with the older stocks of merinos, with marked success. Under native conditions in Australia at least three types of merinos have been developed. First, a fine-wool sheep which fares best on highlands within the temperate coastal zone, where short, sweet grasses are grown; second, the medium-wool sheep which can bear rougher treatment but needs rich and abundant pastures; and lastly the strong-wool sheep, of large frame and tough constitution, adapted to the great "out back" plains where the summer temperature frequently exceeds ninety degrees in the shade and where the food during several weeks in each year consists of sparse, dry grass or salt bush. Naturally, then, when Australian wool is spoken of, unless the variety is specified, it may be either fine, medium, or quite coarse.

General characteristics of the long-wools.—The long-wool sheep are of English origin, as one may judge from the names. These sheep are generally large in size, and their wool is coarse but characteristically long. Leicester wool fiber is often more than a foot long, whereas merino wool seldom exceeds four inches. The long-wool sheep are generally good mutton sheep also.

Leicester sheep.—The Leicester is the oldest true-bred sheep in England. Its wool, although very long and shiny, is rather coarse. The wool is used in making lustrous dress goods, braids, linings, bright serges, etc. The Leicester has been mixed with several other varieties of sheep, particularly the merinos, and one of these crossbreds, the Dishley Merino, is among the best mutton sheep in the world. Pure-bred Leicesters are not frequently found in this country.

Lincoln sheep.—The Lincoln is perhaps the largest sheep in the world. It has a wool which is not only remarkably

heavy, but is, moreover, as long as that of the Leicester. Its luster is excellent. Consequently this wool is used for practically the same purposes as Leicester wool. The Lincoln also is used in crossbreeding, especially with the merino. A very heavy product of fine wool is said to result. Lincoln sheep and their crosses are much in demand on the ranges of western America and in South America. Five thousand dollars for a pure-bred ram is not considered excessive.

Cotswold sheep.—The Cotswold also is much like the Leicester, large, splendidly fleeced, but with wool less lustrous than that of the Lincoln. The Cotswold is frequently used in the western part of the United States for crossbreeding with grade merino ewes. The result of this cross is good, for the lambs are large and fatten readily, while the crossbred wool is abundant and of good quality. Utah and other western ranges have many Cotswold and Cotswold crossbred sheep. Many Cotswold rams are imported from Canada and England for use in the western United States. This breed has been a useful one and is doubtless destined to continued service in the way of crossbreeding with range merinos.

Romney Marsh sheep.—The Romney Marsh or Kent sheep come principally from Kent, England. The breed is similar to the Lincoln, but not quite so large, and its fleece shorter and less lustrous. It furnishes a wool much desired by manufacturers in Germany and elsewhere on the continent of Europe. This sheep is unusually hardy, and fattens on grass alone; hence it is much in demand in such countries as Argentina, Patagonia, Uruguay, and New Zealand. The Romney Marshes are generally crossed with the merinos, the resulting fleece being excellent and of good weight. This variety is not yet well known in the United States, although a few breeding sheep have been imported at very high prices.

In general, the long-wool sheep all produce a heavy weight of wool each year, frequently twice as much in weight as a merino. They are large in body, fairly well suited for mutton purposes, and are greatly desired for crossbreeding with merinos. The wool, however, until crossbred with merino, is too coarse for any but limited uses, such as in lustrous or shiny coarse fabrics.

Wool of the Mutton Varieties of Sheep.—The mutton sheep—the Southdowns, Suffolks, Hampshires, Oxfords, Shropshires, and Dorsets—are generally small, plump sheep, easily fattened, with a tendency to lay on fat rather than to grow wool. The wool is usually of medium length, soft, and fairly fine—the sort of wool much used in flannels, hosiery, and to a certain extent in mixing with longer wools for cloth. The Shropshires are common in Wisconsin largely because of the ease with which they can be cared for and because their wool is reasonably good. They are called the great "farm sheep" of the world because better than any other they combine the mutton- and wool-producing characteristics.

Carpet Wools.—There is still another class of sheep whose wool is in demand for certain special purposes. This wool is poorer than any of those varieties already described. There is a great deal of difference, however, among the wools of this general class, so a general characterization of them is difficult. Under this general class may be grouped all the wools of unimproved native sheep everywhere. Anywhere, the growing of this wool is a sign of indifferent breeding or of natural conditions which prevent the raising of a better breed of sheep. These wools, because of the unfavorable conditions under which they are raised, are "kempy," that is, they have white and dark brittle hairs which resist dyeing; or else they are "cotted," that is, matted or felted together. Such wools range from white to black. The staple is generally coarse and has but few

scales compared with the higher grades of wool. The wools of this class are those most closely resembling hair.

Uses of carpet wools.—Practically none of these wools can be used alone in making the cloth used in garments worn by the American people. When coarse tweeds and cheviots are in favor, some of the best varieties of these wools are used in blending with better wools. They are also used to a limited degree in coarse blankets and felts. The carpet industry, however, uses the great majority of these wools. The best varieties are used for Wilton, Axminster, and Brussels carpets; the poorer grades for ingrain carpets and cheap floor coverings. Because of this extensive use in the manufacture of carpets, this class of wools is known as *carpet wool.*

The use of this term may mislead one, because, as a matter of fact, whenever the regular wools are high in price and the demand for coarse woolen fabrics is strong, the woolen manufacturers mix large quantities of carpet wools with their other wools in making cloakings, overcoatings, and even worsteds. Fashion chiefly determines this matter. When cheviots and homespuns are in vogue, the manufacturer can produce the desired effect very economically by simply mixing with ordinary grades of wool a little carpet wool. On the other hand, to the Russian peasant, what we call carpet wool is good clothing wool. Multitudes dress in garments made by mixing these coarse wools with cow hair. The ordinary bed blanket of the laborer in England is a mixture of coarse India wool and cotton. Blankets of a similar kind are sold in increasing quantities in this country also. Felt boots, horse blankets, wool robes, papermakers' felt aprons, and wadding for gun cartridges are made almost entirely from carpet wools.

Where carpet wool is produced.—Very little carpet wool is produced in the United States, and that little comes mainly from New Mexico. It is called Navajo wool. Prac-

tically none of this wool is produced in England, France, Germany, or Austria, and less than formerly is being produced by Russia, Scotland, South America, Turkey, Persia, India, and China. Carpet wool is not very profitable; consequently, when the natives of a country producing such wools begin to learn something about agricultural improvements, they soon change to better breeds of sheep.

Scotch carpet wools.—Scottish blackfaced or highland sheep produce carpet wools that are strong and long in staple but of poor color. The better staple is used in the making of Brussels, Axminster, and Wilton carpets, most of it being used in Great Britain. American manufacturers buy here only when the prices happen to be low because of temporary market conditions. Usually British manufacturers are in a position to overbid American buyers for this wool.

Russian carpet wools.—The Russian carpet wools are among the best. In the English and American markets such wools are usually called Donskoi wools, but in Russia this name is given to only one particular variety. There are several others, such as the Savolga, Kasan, Tscherskoi, and Kuban wools, all similar in quality but grown in different parts of the empire.

Some excellent grades of carpet wools, the Georgian wools, come from Georgia, a province in southern Russia. Both Donskoi and Georgian wools are much in demand for making velvet, plush, and Axminster carpets.

Asian carpet wools.—Wools from central Asia are known as Bokhara, Turkestan, Merv, Transcaspian, and Calmuc wools. Bokhara wools are shipped from the city of that name. They are gray or black, and are well adapted to felting. Turkestan, Merv, and Transcaspian wools, similar to Bokhara wool, are used in medium grades of carpets such as ingrains and Smyrnas and, to a certain extent, in Axminsters. Much of these wools goes into the manufac-

ture of the felt boots used by lumbermen and farmers in northwestern United States. Calmuc wools are all from the sheep owned by the nomadic Kirghiz tribes. Without proper care or attention, driven about from place to place, living where the land is rough and the pasturage is poor, these sheep produce a rough, coarse, matted wool, which seems to be not so much shorn as torn off the sheep's back. Although there is considerable variation in the quality of Calmuc wools, they all bring the lowest prices and are used in the manufacture of the poorest carpets and rugs. Since the decline of the ingrain carpet and Smyrna rug industry in this country, there has been practically no demand for Calmuc wools in America.

Mongolian carpe wools.—Mongolian wools come to the United States in great quantities for use in carpet manufacturing. Fifteen years ago they were scarcely known in this country, most of the development of this business having come since the Russian-Japanese war. These wools take bright colors well in dyeing and make up into a very springy carpet fabric. All the wool from large areas of central Mongolia comes to this country either through Siberia to the Pacific Ocean, or westward through Russia to the Baltic Sea.

China carpet wools.—China produces much cheap carpet wool of many varieties. Some of it can be made into worsted carpet yarns, some into spun woolen yarns. A little Chinese yarn is fit to go into the finest Wilton or Axminster; the larger part is good for only the poorer carpets.

Wools used in making Oriental rugs.—Turkey, Persia, and India are the chief sources of Oriental rugs. Oriental rugs are made from carpet wools. In these countries some of the best grades of this wool are to be found. The varieties are very numerous, especially from Turkey, Asia Minor, and India. Every locality seems to have a different kind of sheep with wool slightly different from that of

other regions. In general, they are all fair to good in quality. During the last few years there has been a strong demand for Oriental rugs, resulting naturally in increasing prices on these wools.

Carpet wools imported by the United States.—American manufacturers buy from these countries and then usually mix with the carpet wools obtained from elsewhere. The variety of Persian wool chiefly used in this country is called Khorassan; it takes color well and is used in Axminsters.

From the northwestern part of Asia Minor come Angora, Caramanian, Samsoun, Yosgat, Smyrna, Yerli, Bouldour, and Konich wools; from Syria come Aleppo, Orfa, Damascus, and Jaffa wools; and from Mesopotamia come Bagdad, Awassi or Mossoul, Kerkouk, Karadi, and Bussorah wools.

The "Oriental Rug Trust."—Smyrna is the center of the Turkish oriental rug manufacturing business. There are in this city over 45,000 hand looms under one concern, a sort of oriental rug "trust." These oriental rug manufacturers are today the principal competitors of the manufacturers of high-grade American rugs, not only in buying the raw material, but likewise in selling the finished products.

India carpet wools.—India produces a considerable variety of wools ranging from the poorest grades up to those which are suited for the finest rugs. The best include such varieties as Joria, Vicanere, and Kandahar wools. All are largely used by local Oriental rug weavers, and also by foreign manufacturers in making Wilton, Axminster, and Brussels carpets.

Food for the sheep.—The nature of the pasturage markedly affects the character of all kinds of wool. Rich soil, with a rich vegetation of sweet, soft grasses, causes a fine wool to grow. Chalky soils, such as are found in southern England, produce feed that has the effect of making the wool coarse. It is to be noted that the alkali in certain

parts of the western United States makes more wiry the wool of sheep pastured there.

Climate.—Climatic conditions cause wool to vary. In dry regions the wool seems to become more like hair, if one may judge from the native or wild sheep; whereas in moist climates the fiber becomes longer and more crimpy. Wool is nature's covering for the sheep against cold and wet, and wherever cold and wet are characteristic, sheep have the longest, heaviest wools, and, unfortunately, usually the coarsest also.

Differences in seasons.—Differences in seasons produce differences in wool of a given locality. A dry, warm season causes sheep to have short, fine, resilient wool, while a rainy season means long, heavy, matted fiber. The nature of the shelter given the sheep also affects the wool. Poorly cared for, unsheltered, badly fed sheep always have the poorest wools.

Health of sheep.—A sheep in good health produces a good growth of its particular kind of wool; bad health as directly causes the wool to be poor. There are a number of disastrous diseases affecting sheep, such as anthrax, foot and mouth disease, stomach worms, scabs, etc., ailments which good sheep farming is successful in preventing.

Cleanliness.—Other factors conspicuously affect the quality of the wool as it comes from the sheep's back—cleanliness, for example. All wool naturally contains grease and perspiration that comes from the sheep's skin. Both lodge in the wool. Both help to keep the sheep warm during the winter time. These substances collectively are generally called the "yolk" or "suint," although the inclusive name "grease" is more frequently applied. Furthermore, sheep gather many foreign impurities that stick in the wool and grease. Dust, burrs, seeds, chaff, and manure are common. In dry regions, dust is likely to be the chief impurity imbedded in the wool. In our American middle-western pas-

tures, sheep catch burrs, thistles, seeds, etc., in their wool. The careless farmers of Wisconsin and elsewhere in the Middle West let their sheep run loose in the strawstacks during the winter time. Here the neck and back wool of the sheep become filled with chaff. The very worst cases of this kind are to be seen where the strawstacks contain threshed barley, the beards of which penetrate the wool at every part of the body and work into the sheep's skin. Not only is the wool lowered in quality, but the sheep itself is made uncomfortable.

Relation of Cleanliness to Price.—When wool is sold by the farmer to the dealers, account must be taken of all these impurities, for the price is determined not only by the variety of the wool but also by its cleanliness. Since it is sold by weight, all impurities and all moisture must be discounted in the price. Sheep farmers often wonder why their neighbors who have the same varieties of sheep and who have similar pasturage and feed get several cents more a pound for their wool. The explanation is in many cases that the neighbors' sheep have been better cared for and have been kept cleaner.

Difficulties of Classifying Wool.—On account of the many conditions affecting the quality of the wool for textile purposes, it is not possible to classify wool soleiy according to the varieties of sheep, although that would seem to be the most natural classification. One classification has divided wool into three large classes: namely, carding, combing, and carpet wools. This classification had its value when only the longer varieties of wool could be combed, but today very short wool is being combed by improved machinery; the long wools are often carded and not combed; while the carpet wools, as we have seen, are not always used for carpets. Nor is any classification based upon use possible, for the average fiber can be used for a number of purposes. In the tariff schedules of the United

States government, wool is divided into classes I, II, and III, based on the old carding, combing, and carpet wool division, but few people see anything praiseworthy about this unscientific law and its classifications. Schedule K, the part of the tariff law applying to wool, was declared indefensible by President Taft, and a Tariff Commission was set to work to determine remedies in classifications as well as in charges to be made by the government.

HOW THE MANUFACTURER BUYS WOOL

The wool manufacturer buys wool for certain uses. He has certain goods to be made, requiring definite qualities of wool. His buyers go into the markets of the world and buy wool that corresponds to those qualities, disregarding its name or its place of origin, so long as the price is satisfactory. If he cannot find a single variety that will answer his purpose, he will take two or more approximating what he wants and mix these in proper proportions.

Standard grades of wool.—Because of the variety of sheep raised, and because of the conditions under which they are raised, certain communities come to be known in the markets as sources of supply for certain grades and qualities of wool.

Saxon wool.—For example, we have already seen that Saxony produces a fine type of merino sheep. These sheep get excellent care as a rule, and the raw wool that comes from Saxony is, for its size, the finest, softest, most elastic fiber in the world. Every fiber has multitudes of scales or serrations; hence the Saxon wool has excellent felting qualities. This wool is in demand at high prices for use in making the finest dress fabrics. Wool manufacturers, then, look regularly to Saxony for wool of this grade.

Australia produces greater quantities of good wool than

any other country. But not all of the Australian merino is of good grade, as we have already seen. Certain places in Australia have a reputation for particular qualities in wool, as for example, Port Phillip, Sydney, and Adelaide.

Port Phillip wool.—Port Phillip wool ranks almost as high as fine Saxon wool. Its color is good. It mats well. It spins yarn as high as 130's, and is used largely in fine worsted and woolen dress goods. Port Phillip wool is therefore a standard fine wool, so recognized in all big markets of the world.

Sydney wool.—Sydney wools are not so fine as those of Port Phillip, not so strong, nor so uniform in length. However, they are used in making medium and better grades of worsteds as well as woolens.

Adelaide wool.—Adelaide wool averages yet lower in color and other qualities. Being a very greasy wool, it shrinks much in washing. This wool is used in making medium fancy woolens and worsted dress goods. It will spin filling yarn up to size 60's.

These three varieties of Australian wool, Port Phillip, Sydney, and Adelaide, are the standard Australian fine wools, but there are several grades of each, and the poorer Port Phillip wools may be worth many cents a pound less than some good grades of scrub sheep wool from Wisconsin or Minnesota. These three Australian wools are merinos. In addition to these, Australia sends out great quantities of crossbred wool varying greatly in value and in quality, ranging from common and coarse to fine and superfine.

Van wool.—Van wool from Tasmania is a high grade of very white fiber that takes light dyes and hence is in strong demand for fancy dress fabrics.

New Zealand wool.—New Zealand wool is an excellent wool with exceptional qualities of elasticity, and is easy to spin. Because of these qualities this wool is very useful for

mixing with shoddy and other wool substitutes to give these materials the springiness and bulk of pure, fresh wool.

Cape wool.—South African wools, usually called Cape wools, vary from the finest to the coarsest. "Cape Snow White" compares favorably with the best Australian wool. Its peculiar whiteness fits it for use in the finest classes of dress goods. In general Cape wools are rather tender, less wavy, and less elastic than Australian wools and do not felt so well. On this account Cape wools are often made up into hosiery, shawls, and cloths where felting is not desired.

South American wools.—South American wools are usually not so strong, so elastic, or so satisfactory to felt as Australian wools, but they are improving rapidly with the better methods of sheep raising that are being introduced into Argentina and Uruguay; not improbably, then, the South American wools will before long rank above the average. It is not likely, however, that these countries will raise the finest wools, for the same reason that the Eastern United States no longer raises merino wools in great quantities. A fine wool sheep does not pay so well as a sheep that combines fair wool and good mutton qualities. During the last few years South American mutton has been in great demand in Europe. It is shipped by boat loads in steamers with refrigerator arrangements, and therefore arrives in Europe in a frozen condition.

American wools and their classes.—The American wools vary from the finest to the poorest. There are several classifications, some that apply only to certain states, as, for example, New Mexico, with its numbers 1, 2, 3, and 4 wool, and California with its spring, northern, and fall wools. In California the sheep are sheared twice a year, the fall wool being worth less than the spring clip. In general, however, the American wools, particularly of the Eastern states, are classified as follows:

The finest quality is called "picklock." This grade does

not appear in the market quotations, because it is very scarce. It is the quality produced by a pure Saxony merino sheep of which some were imported into Pennsylvania and Ohio about fifty years ago.

"XXX" wool is produced by a cross of the common American merino and Saxony merino.

"XX" wool is from a full-blooded merino.

"X" wool is from a full-blood or high-grade merino.

"Half-blood," "three-eighths-blood," "quarter-blood" wools indicate varying percentages of merino blood in the sheep producing the wool.

What the terms mean.—It should be noted, however, that these terms refer, in the trade, not so much to the blood in the sheep which produced the wool as to the relative coarseness and fineness of the fiber. To be sure, the more merino blood in a sheep, the finer, as a rule, the wool is; but it is possible to have a wool of, say, three-eighths-blood quality either on an English crossbred or on a practically full-blooded merino. The terms "fine," "half-blood," "three-eighths-blood," "quarter-blood," etc., have in fact no necessary connection with the proportion of merino blood in the sheep which produced the wool so designated.

"Fine Delaine" is a straight merino wool some two and one-half inches long, adapted to combing.

"Braid" wool is a coarse wool, generally lustrous.

To each of these terms is generally prefixed the name of the state from which the wool comes; hence there may be Ohio three-eighths-blood, Wisconsin three-eighths-blood, or Missouri three-eighths-blood, and so on for all the rest of the varieties.

English method of grading wool.—To the manufacturer each grading term suggests the working and spinning quality of the wool. In England such designations or market terms for wool are displaced by the more direct naming according to the size of yarn that the wool will produce,

as for example, 30's, 50's, 70's, etc. The American class known as quarter-blood would in England be called anywhere from 42's to 50's wool; half-blood would be called 58's to 60's; and X wool would probably be called from 64's to 70's. No. 60's wool is the English standard for comparison of prices. If one were to ask a British wool merchant the price of wool, he would invariably give it for the 60's grade, unless other grades were specified.

Special classes of wools.—The preceding are the regular classes of wool obtained by shearing full-grown sheep at the regular times. There are, in addition, other varieties of wool, obtained by other methods and having quite different qualities.

Lamb's wool.—Lamb's wool is obtained by shearing the lambs before they are a year old, generally at the age of six or eight months.

Hogg wool.—"Teg," "hogg," or "hogget" wool is wool from a year-old sheep which has not previously been clipped. The fiber is pointed and tapers towards the end. This is nearly all made into warp yarn.

"Shurled hogget" wool is the first-class fleece from a sheep which has previously been shorn when a lamb.

Wether wool.—"Wether" wool in the United States is the name given to the wool produced on a castrated male sheep. In England, however, wether wool is any wool shorn after the first or hogget fleece has been removed.

Pulled wool.—"Pulled" wool is that which is removed from the skins of slaughtered sheep. Pulled wool is a by-product of the slaughtering and meat-packing industries in this country. Argentina, Australia, Africa, and other countries send a large proportion of the skins taken from the carcasses direct to Europe without any preparation. The city of Mazamet, France, is the center of the world's trade in these skins. During 1910, this city received and pulled the wool from more than 130,000,000 sheep skins.

In Mazamet the wool is first loosened from the skin by a rotting process. In this country and in Australia the wool is loosened by chemical means, either sodium sulphide or lime being used. Whatever the process there is likelihood of injuring the wool fiber; hence pulled wools are used only in medium and low grades of goods. They are used extensively for blending with shoddy, noils, and wastes. They lack spinning properties, are harsh, and do not work up like "fleece" wools, but are a valuable raw textile material and are sure to increase in importance with the growing emphasis which is being placed on raising sheep for mutton as well as wool.

Conclusion.—From the foregoing it will be seen that there are very many varieties of wool. In fact experience in grading United States wools has shown that even a system with two hundred defined grades is inadequate. Every locality has its own peculiar conditions affecting the wool. Furthermore, qualities vary endlessly according to the numerous varieties of sheep, their feed, care, cleanliness, the climate, the time of shearing, the health and age of the sheep, and other factors which all go to produce a wool with definite individual characteristics.

CHAPTER XI

THE PRODUCTION OF WOOL

The United States produces annually something over 300,000,000 pounds of wool as it comes from the sheep's back. The people each year use, on an average, between five and six pounds for every man, woman, and child; hence there must be imported almost as much as we produce at home. The production within the United States in 1910 was 321,400,000 pounds, while the importations amounted to 252,000,000 pounds. The sources of our raw wool will prove more significant in the future, for according to the census of 1910, there were then about 14 per cent fewer sheep in this country than there were in 1900, ten years before. During these ten years the number of sheep fell off in more than three-fourths of the states in the Union. In some states the drop in numbers was as much as half. Evidently if we allow this decrease in production to continue, we shall have to rely more and more upon foreign countries for our supply.

Why wool production is falling off in the United States.—It is well to know something about the conditions of sheep and wool production in this country so that this tendency to discontinue sheep raising may be traced intelligently. Possibly some of the causes for this tendency may be removed or at least modified. It may be that some of them will become inoperative in the future. In any case the student should intelligently follow this movement during the coming years.

Not profitable.—The fundamental reason for the lessening of sheep in America is that the farmers find that under the present methods of farming they can make more money producing something else. The average market value of a sheep in this country in 1910 was about $4.40. The cost of keeping sheep averages about $4.00 per head per year, counting all expenses, value of investment, etc. The principal products are wool and lambs. The average weight of the fleece of an American sheep is less than seven pounds. At an average sales price of twenty-five cents a pound, the wool brings about $1.75. Flocks that double in number in a year are considered very good. If this increase in lambs were sold at the average value of lambs as given in the census for 1910, then there would be a product of about $2.30 for each lamb. Each sheep in the flock could then be credited with a fleece at $1.75 and a lamb at $2.30, or a total of $4.05. This leaves a net profit of five cents a sheep—too narrow a margin in view of the facts that only the better grades of wool sell for twenty-five cents a pound, that the price fluctuates considerably, and that the cost of keeping sheep varies from year to year. It is easy to see why many farmers lose money on sheep raising. The margin of profit is never very wide. Careful accounts of nine typical Minnesota flocks kept by the Minnesota Agricultural College showed for each sheep an average cost of $4.13 and an average income of $4.38.

Western ranges raise sheep at considerably less cost, but the product on each sheep is generally less also. The figures that have been given should be considered only as averages. Few actual cases will be found exactly the same as these. The point emphasized is the narrow profit margin in sheep production in this country. Many who have scientifically studied sheep raising say that it is possible to raise sheep in this country at a satisfactory profit. The fact is that while certain farmers are able to raise sheep profitably,

their methods and their knowledge of the business are not general. It is one of the chief purposes of agricultural colleges the country over to teach better methods of production; some of these colleges have made special study of this particular subject of sheep and wool production.

Depredations of dogs.—Not only the financial consideration prevents farmers from raising sheep. Strange as it may seem, sheep raising has fallen off considerably in several portions of this country because of the depredations of dogs. Vermont is an example, according to some who have grown sheep there. The same is true of Massachusetts, New York, and even Wisconsin. In Kansas, where there are more dogs than sheep, the sheep owners declare that the owners of dogs cannot be made to believe that their dogs are the culprits; hence trouble arises. Where dog owners outnumber the raisers of sheep, the latter frequently stop raising sheep. It should be added that much of the sheep destruction by dogs is due to stray curs, an evil that a good licensing system would remedy.

Competition of the dairy industry.—Another factor checking the production of sheep is the growth of the dairy industry. In southern Wisconsin, formerly a great sheep section, dairy cattle have been substituted to the full limit of pasturage and feed. The Wisconsin College of Agriculture maintains that this is a mistake. They assert that if the farmer would raise fewer cows and would add small flocks of sheep, the net profits would be as great and the farm kept in better condition.

High cost of fencing.—Another drawback to sheep raising in the northern part of Wisconsin is the high first expense for fencing. Cattle can be kept within a pasture by the use of only three barbed wires placed at the proper height; whereas sheep require five wires, or better still, woven wire fencing. The immediate expense of such fencing deters new farmers from going into sheep raising. The

narrow margin of profit, the dangers of sheep diseases, and the lack of knowledge about sheep are some of the other reasons why sheep raising is on the decline in the Middle West.

Methods of wool production in this country.—The methods of wool production differ widely in the different parts of the country. For example, in the West, sheep raising is conducted as a distinct occupation on large ranches, huge flocks of sheep being raised on a single ranch containing its thousands of acres. In the eastern part of the country the industry of sheep raising is carried on rather incidentally on grain or dairy farms. In Wisconsin the average number of sheep on the farms that raise sheep at all is less than twenty. This may be taken as typical of sheep production in all parts of the country except in the sheep-ranching area. The sheep ranches require special labor, sheep herders, camp tenders, and shearers, an average of one man for every 1,500 head of sheep, and extra help during lambing and shearing times. In the dairy and grain-farming states, the sheep are usually given only a part of the time of the farmer, allowed to run in the pastures with the cattle, and stabled just as the cattle are in the winter time. In the West, the sheep ranch land is used for nothing else. In fact close grazing unfits the land for other livestock pasturage for several seasons. Sheep ranching has frequently paid well in the past, but is, nevertheless, a hazardous and lonesome occupation. The sheep herder stays out for long periods of time with his flocks, seeing no human being save the camp tender. Few men can stand the strain without undue mental suffering. Most of the herders are Mexicans and Indians, who seem less susceptible to this danger.

Possibilities of loss on sheep ranches.—There is always possibility of great loss of sheep from storms during the winter. During blizzards whole flocks of many thousands

of sheep may be killed. Poisonous plants kill some sheep every year. Coyotes and wildcats, especially the former, constantly follow the ranch flocks, stealing in and killing sheep whenever the herder with his rifle is off his guard. In times of excessive drought, both the feed and water may disappear; whereupon the sheep must be driven long distances to new pastures and to water. Many sheep are likely to fall dead by the wayside on these journeys.

There is usually considerable loss of both ewes and young lambs at lambing time. For weeks after the lambs are born, there is constant likelihood of the lambs being separated from the mothers, and starving to death. At least 10 per cent of the lambs die thus on the sheep ranches. Large numbers of sheep are often shipped eastward and divided up among eastern farmers for the purpose of fattening them for market, with probable losses at every move. Sheep ranching has almost as many chances as gambling. During the last few years, therefore, there has been a steady decrease in the number and size of these ranches. Irrigation and dry farming have crept in. The sheep rancher has been compelled either to retreat to more arid regions, or to sell out his flocks, very frequently the latter. We may not look forward to any increase in sheep ranching in this country. Sheep and wool production will grow only with the spread of diversified farming, and in the humid regions.

Shearing.—Shearing is now usually done in May. June shearing, formerly common, is now thought less practicable, the sheep doing better and the wool product being finer from the earlier shearing. The average fleece in Wisconsin weighs from seven to eight and one-half pounds, a fair average for the varieties raised, mainly Shropshires and Oxfords.

The shearing is done either by hand shears or by machine clippers. Since the introduction of the machine wool clippers, the sheep with folds in their skin have not been popu-

lar. The older merinos had deep folds, and sheep raisers everywhere tried to breed so as to make them still deeper; they reasoned that the deeper the folds the greater the skin surface, and the greater the skin surface, the greater the amount of wool on each sheep. Now farmers everywhere desire the sheep with smooth skin, preferring rather to increase the size of the body by crossbreeding the merinos and other fine wool sheep with the large, bony, long-wool types.

The fleece.—If the shearing is done well, the wool from the sheep holds together in one large sheet. This sheet, called the fleece, is rolled up and tied, with the dirty outer side of the wool turned in. Sometimes two fleeces are tied together in the same bundle. The fleeces are either stored by the farmers in the hope that prices may rise, or else immediately hauled by wagon loads to market.

Wool washing.—In some localities the wool is washed before being hauled to market, frequently while on the sheep's back, by giving the sheep a bath in a tank, but this practice seems to be on the decrease. The improved washing machinery found in wool manufactories has made it unprofitable for the farmer to wash wool by hand in his ordinary tubs or tanks. The result from wool washing on the farm is so uneven that there can be no assurance of proper remuneration for the work.

CHAPTER XII

WOOL MARKETING

Local wool marketing.—The American wool grower disposes of his raw wool in a variety of ways, depending upon the locality, the amount of wool offered for sale, the customs of marketing, the wool grower's knowledge and shrewdness in marketing, the opportunity for coöperation among wool growers, and other factors of less importance. Wool growers who produce large quantities are generally able to get better prices than small producers. Competition among buyers leads to better prices, whereas combination among the buyers, with consequent lack of competition, leads to lower prices for the wool.

Sales to local dealer.—The method of marketing wool most common among the farmers in the eastern and Mississippi Valley states is that of selling to local dealers in near-by towns, men who usually combine wool buying with other business, grain buying perhaps, or storekeeping. The local dealer examines the wool that is brought to him, estimates its value as well as he can, and then offers a price which he thinks will give him a profit when he in turn sells the wool to some merchant, commission house, or manufacturing concern. Sometimes the local dealer ships all the wool he buys to some commission house or wool merchant. In a word, he may act as the buying agent for such a concern, the concern supplying him with buying funds and otherwise assisting him in getting the raw wool.

Selling to local dealers is not always entirely satisfactory.

The dealer's judgment of the quality of wool may not invariably be good, for wool judging is a most difficult art. Good wool brought to such markets often brings less than it should because of willful or ignorant failure to rate it fairly. Producing better grades of wool is therefore not always encouraged by this system. Sometimes, it is alleged, local dealers buy high-grade wools at low-grade prices, the wool growers themselves not being sure of the grades of their wool; these dealers then sell the same wools at a profit illegitimately large. Such practices have made growers suspicious of middlemen in wool, and have led them to seek other methods of marketing their product.

Sales to commission houses.—Large wool growers, especially those in the western states, often send their wool direct to commission houses or wool merchants in Boston, Chicago, or Philadelphia. In these cases the wool is hauled to the railroads, loaded upon the trains, and sent east by the grower, not being judged or graded until it arrives at the commission house or other destination. These transactions are often completed entirely by mail, although representatives of the commission houses frequently travel throughout the wool-growing country, making contracts for the wool at stipulated prices, sometimes long before shearing time. Under this system, the wool is graded very carefully by experts; as a general rule, therefore, there is little complaint of such unfairness as is found in selling to local wool buyers.

Sales by auction.—Another system of marketing is to be found in the sheep-range country of the West; namely that of auctions. This is the regular marketing method of Australia and New Zealand, but has been used only slightly in this country. The method of procedure is as follows: On a given date after shearing time all the wool is brought to town, and put up at auction in various lots. Buyers from wool-manufacturing and commission houses have

been notified of the date, and all who are interested are represented at the auction.

Sales direct to mills.—In certain parts of the Middle West, the growers sell their wool direct to factories, or to the representatives of factories. Woolen mills that buy in this way are scattered throughout Iowa, Minnesota, Wisconsin, Tennessee, and Ohio. Each mill buys as much as possible direct from the near-by farmers, to the advantage of both parties. The buying expense of the mills is reduced, while the farmers get a slightly higher price for their wool than they can get from the average middleman.

Farmers' coöperative sales agencies.—In a few cases farmers' coöperative associations take charge of the wool produced by the members, selling it either to dealers or to manufacturers in amounts large enough to get the fairest prices. The Minnesota Wool Growers' Association not only collects the wool from its members, but also manufactures woolen goods in its own mills. In this particular case the results are said to be very satisfactory to the wool growers.

Wool merchants.—The wool that does not go direct from grower to manufacturer goes to the great wool markets of the country for resale, storage, regrading, etc. Boston is the great wool market of the country. Many of the oldest wool merchant houses are located there, and the largest woolen mills in America are only a few hours' ride from the city. Philadelphia and Chicago rank next as centers for this country's home trade in raw wool.

Wool warehouses.—In these cities are found large storage buildings in which the wool may be kept until demanded by manufacturers. Boston has a wool warehouse large enough to hold 100,000,000 pounds, all immediately accessible. It is thus possible to store almost one-third of the nation's annual clip in this one building. The American Woolen Company is said to control the corporation owning

this structure, and to buy most of the wool stored therein.

Other large warehouses are to be found in Philadelphia, New York, Chicago, and in the western wool concentration points at Billings, Big Timber, and Great Falls, Montana, at San Francisco, and in several other west coast cities.

Functions of wool merchants.—The wool merchants occupy an important place in the present system of wool marketing. Most of them have large capital that can be used in buying large quantities of wool on cash terms, often long before any sales can be made to manufacturers. Since their sales to manufacturers are often on credit, they may have money tied up not only in the wool stock in their warehouses, but also in manufacturers' goods in process of making. This extension of credit to manufacturers is naturally a function of banking; hence such merchants are sometimes called wool merchant bankers or textile bankers.

These wool merchants also exercise their banking function at times with regard to the producers of raw wool, especially in the range country. A sheep rancher finding himself short of funds to pay the wages of the herders and the other expenses that come up before the time for selling the wool, often makes an agreement with an eastern wool merchant whereby the merchant lends him the desired amount and takes a lien on the unshorn wool. In other cases the merchant buys the wool outright to be delivered at the proper season. The wool merchant's need of large capital is thus clear. He may have money invested in wool yet on the sheep's back, in wool stored in some warehouse waiting for a buyer, and in wool in process of manufacture.

Buying wool "on the sheep's back" often takes a speculative turn. Merchants, on looking over the world's sources of probable wool supply during a coming season, may conclude that this supply will be inadequate for the demand and that consequently prices will go up. In such a case

some of the merchants are likely to try to gain an advantage from the expected rise in prices by going into the wool-producing territory and offering to buy at advantageous prices the wool still growing on the sheep. In 1909 such an advance in price was expected, and an unusual quantity of western wool was sold by contract to eastern merchants long before the sheep were shorn. Some of this early buying takes place every year.

In addition to buying, selling, and financing the wool business, the wool merchants also perform various necessary functions, such as accumulating large supplies of wool in certain centers patronized by manufacturers. These merchants are likewise the importers of foreign wool. Much of this is purchased by their representatives in the great wool markets abroad, in London, Liverpool, Cape Town, Buenos Aires, or Sydney. When the wool comes to the warehouses, it is graded carefully and then stored in such manner that any quantity of any grade may conveniently be taken out, sold, and delivered to manufacturers. A manufacturer can thus generally go to a big wool merchant and get without difficulty just such grades of wool as he wants in the proper quantities.

Eliminating the wool merchant.—For these services, the wool merchant charges his profit. Some have thought this profit too large and have attempted to eliminate the wool merchant, or "middleman" as he is called, by having sales made direct from producers or local dealers to manufacturers. Various systems of handling the wool have been proposed, among which coöperative organizations of producers have been quite prominent on the one hand, and large associations of manufacturers buying direct through their own organization on the other. Furthermore several wool growers' associations have been formed, but so recently that it is hard to say whether or not they will be successful in marketing their product. Most of the first at-

tempts ended in failure. Buying direct by manufacturers seems to be increasing in direct ratio with the increase in concentration of capital in the wool-manufacturing industry. The small wool factory must of necessity buy through the merchants except in limited and exceptional cases. The large corporation controlling several woolen mills can provide a buying organization comparable in every way to that of the wool merchants.

The auction system of marketing.—The systems of marketing in Argentina, Uruguay, and Russia are similar to that of America; that is, the wool is generally bought and sold by private buyers and sellers under ordinary marketing arrangements. But in England, or at any rate in London and Liverpool, and also in Australia, New Zealand, South Africa, and in the German markets, wool is generally sold at public auctions held on prescribed dates. The wool markets of these countries are controlled by public or semipublic bodies, the wool is graded by official graders, and sold (in much the same way as wheat or cotton in the large American exchanges) by grade instead of by sample.

Auctions in this country.—The auction system has been tried in this country several times during the last few years, but with no success. In 1894 the New York Wool Exchange was established with the idea of conducting the wool business on the same basis as cotton marketing. Auctions were announced, but both buyers and sellers failed to appear. Within four years the system had to be abandoned, and the New York Wool Exchange passed out of existence. In 1908 the Wyoming Wool Growers' Association established an auction system and built a wool warehouse at Omaha; this enterprise also failed within a year. In 1909 the National Wool Warehouse and Storage Company of Chicago was formed, a large warehouse was built, and the auction system again attempted. The auctions failed, but the company, instead of passing out of existence,

undertook to buy and sell wool on commissions in the fashion of some wool merchants. The National Wool Growers' Association aided this company financially, and its success as a commission house seems assured.

Why the auction system fails in this country.—The auction system which works well in England and Australia is so unsuccessful in the United States largely because of unevenness in American wool qualities, and because of the business habits of our people. Australian wool, while of many grades, is fairly uniform as compared with wool produced in the United States. Australian, English, Cape, and German wools can be graded evenly since the sheep raised in each of these countries are of fairly constant breeds, and the conditions of production are generally about the same. Not so in the United States! The New York Wool Exchange began by defining two hundred grades of wool under which they expected to handle the American product. Within a short time it was found that this number of grades was entirely inadequate. No system of grading for American wools has yet been found applicable in the public market. Sheep raising in this country must first be so standardized in each section that there will be no such continual change as now exists from breed to breed or from one condition of production to another.

A second reason for the failure of public wool auctions in this country is to be found in the psychology of the American wool producer and dealer. Regulations and market rules are more or less odious to him. What he wants is a direct chance to sell or to buy, and to exercise his bargaining instincts in every possible way. That he risks considerable loss in his private bargaining because of mistakes in judgment or because of fraud or deception, weighs not half so heavily with him as the sporting chance of winning something more than would be possible in the regulated public market. It is only another illustration of the domi-

nant idea among so many of our American business men, "to get rich quick," and the willingness to "take a chance." In the European markets, conservatism marks the trader rather than plunging. He takes a lower margin, but he is more secure in this margin. He has learned the lesson that plunging has too many probabilities of disaster to be profitable in the long run.

Factors of successful marketing.—Successful wool marketing calls for special facilities for so handling and storing the wool that such quantities of any quality may be procured and later distributed as demanded by wool manufacturers. Somewhere in the system such means must be provided. No adequate method of holding back the wool on the farms or ranches until needed by the manufacturers has yet been suggested. Local dealers cannot do this holding any better than the wool growers can. Most manufacturers find outlet for practically all of their capital in the production and marketing of the finished goods. To organize the buying of raw wool too would be more than any save the very largest companies could do. The present system of collecting, sorting, and storing wools through the medium of the great wool merchant houses has much to recommend it as regards economy and efficiency.

Marketing of wool also calls for an expert knowledge of qualities. Not only are there the great number of grades mentioned in preceding chapters, but there are qualities or grades within grades. Dirt, grease, dead, straight, shiny fibers called "kemp," and matted wool all detract from the value of the wool. Consider, for instance, the item of natural grease found in wool as it comes from the sheep. What part of the total weight of the fleece shall be allowed for it? What part of the fleece is grease and what part pure wool? In the washing or scouring processes all of this grease comes out. The shrinkage in scouring varies from 10 per cent to 75 per cent of the original weight, no two

kinds of wool being likely to show the same shrinkage. Nor are any two sheep likely to have the same amount of grease in their wool even when raised under the same conditions. In fact the same sheep will have differing amounts of grease in its wool in different seasons. Yet certain varieties raised under given conditions come to have a fairly uniform shrinkage. This is the basis upon which most buyers work. For example, the full-blood, half-blood, and crossbred sheep under a given environment will each probably have a certain percentage of grease; and each variety will have a different percentage for every different environment. To illustrate: in Wisconsin each pound of three-eighths-blood fleece usually sells for a few cents less than does the Ohio three-eighths-blood, the reason being that Wisconsin wool shrinks more in the scouring. Probably the causes are differences in climate, food, and care. But whatever the causes, the conditions as outlined exist and must be considered in the markets.

CHAPTER XIII

THE MANUFACTURE OF WOOL

Storage of wool.—Most woolen mills have storehouses for the raw wool as it comes from the markets. Here the wool is piled up in proper order so that the various qualities may be readily found whenever wanted. The stock-keeping system usually employed here is very much like that of the retail storekeeper.

Wool sorting.—The first step in the manufacture of wool is the sorting. The fleeces come to the factory tied in bundles as they left the farms or sheep ranches, several fleeces often being packed in one large bag weighing several hundred pounds. These bags are brought into the sorting room and opened. The strings holding the bundles are cut and the fleeces are spread out on tables, placed preferably in a good north light, for the sorters who work at the tables must have the best lighting conditions in distinguishing the various kinds or qualities of wool in a fleece. The top of the table is usually made of wire netting to permit dust, sand, and other dirt to fall through when loosened from the wool.

We have seen that there are numerous kinds of wool. But the varieties do not stop with the classifications as outlined in previous chapters. Every fleece comprises several kinds of wool. The wool is not uniform over the entire body of the sheep. Some parts are longer than others, some are finer, some cleaner. The fleece, then, must be duly divided into parts in order to get the uniform wool desired. The best wool comes from the sides of the sheep, the next

best from the back and thighs, that from the belly and throat is inferior, and the poorest wool comes from the breech and lower part of the legs. In some cases the fleece is divided into more than these four classes of wool. In fact, mills making fine woolens and worsteds may distinguish from eight to ten or even more classes of wool in the average fleece.

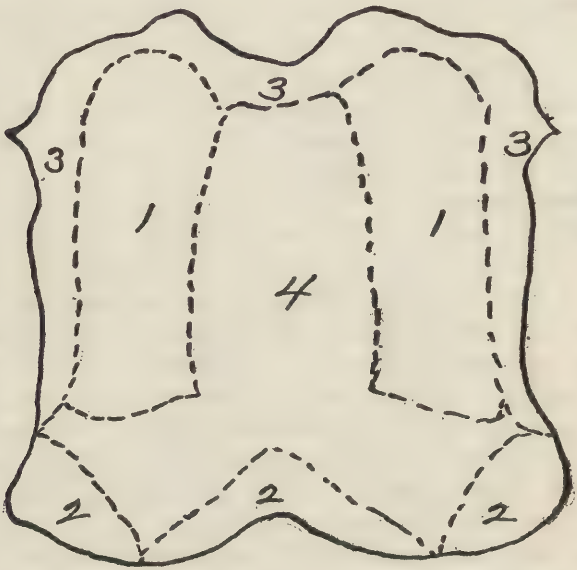


DIAGRAM OF A SHEEP'S FLEECE, SHOWING GRADES OF WOOL.

1. Best grades.
2. Lowest grades.
3. Fair grades.
4. Medium grades.

In the woolen trade these classes are known as picklock, prime, choice, super, head, downrights, seconds, abbs, and breech. In the worsted trade somewhat different terms are used for the different classes. Here the usual classes are fine, blue, neat, brown drawings, breech, cowtail, brokes, and so on down the range of quality. Another system of

classification is the naming of each class by the number of yarn that it will make, as for example 40's, 60's, and 80's wool.

The finest wool grows over the finest flesh on the sheep. The following table gives a good general idea of the grades of wool found in a single fleece.

GRADES OF WOOL IN A FLEECE

Head and sides of sheep	Long, uniform, the best of the sheep
Lower part of back	Slightly less fine and not so soft
Loin and back	Still less fine, rather tender
Upper part of legs	Medium coarse
Upper portions of neck	Inferior
Central part of neck	Inferior
Belly	Poor quality, short, dirty
Root of tail	Coarse, short, glossy
Lower part of legs	Dirty, greasy, straight, coarse
Head	Stiff, straight, coarse, full of fodder
Throat	Stiff, straight, coarse, full of fodder
Chest	Stiff, straight, coarse, full of fodder
Shins	Glossy, straight

Method of sorting wool in fleeces.—The wool sorter first divides the fleece into two parts along the line of the back. Next he cleans out the worst part of the wool, the lumps of dirt, large burrs, and other roughage. Beginning thus on the outer edges he works inward on the fleece, tearing the wool out with his hands and throwing the various grades of wool into various piles or baskets, or sometimes into holes in the floor that lead to bins on a lower floor.

The job of sorting wool is not particularly pleasing or cleanly. The wool is always greasy and often very dirty, and not infrequently filled with sharp thistles, thorns, and burrs. The wool sorter grows accustomed to this, his hands finally growing so hard that the ordinary impurities in the wool have no effect on them. When the sheep have been diseased, there is danger of the sorter contracting the same disease, although with ordinary care the wool sorter is as

safe as a workman in any other occupation. Of course, all danger from disease is entirely done away with in the washing and scouring processes that follow.

Wool scouring.—After the wool is sorted, it must be washed. Some of the foreign substances in the raw wool can be removed simply by washing in water, but the grease requires a solvent such as soap or gasolene. There are two kinds of common alkalies used in the manufacture of soap, caustic potash and caustic soda. The latter is cheaper but the potash is safer for use on wool, since the caustic soda is likely to cause damage to the finer fibers. Hence caustic potash soap is more generally used in washing wool. Several other cleansing substances are frequently employed, such as ammonia, special preparations like Wyandotte Textile soda, and sal ammoniac. To a certain extent gasolene or some form of petroleum naphtha is used to remove the grease, especially in very large mills. It is excellent for this purpose, but the wool still requires washing after its use; this process therefore takes more time and money than soap washing, and is naturally not widely used by the wool manufacturers.

Mechanical scourers.—The wool is generally washed in large vats or tanks arranged in series, the length of the whole apparatus often being more than fifty feet. These vats or tubs are fitted with mechanical rakes which drag the wool through the suds. The temperature of the water is a matter of importance. If allowed to get too hot, the wool will lose its fluffiness; if the water is too cold, it is hard to wash out the grease. The usual temperature is below 120 degrees Fahrenheit, about that preferred in careful laundries in washing woolens. Naturally the temperature should be somewhat adjusted to the kind of wool, to its fineness, and to the amount of dirt therein.

After being washed thoroughly in from one to three vats of suds, and wrung out after each washing by being

passed through heavy wringers fixed at the end of each vat, the wool is finally rinsed in warm clean water, and the washing is completed. The whole process takes less than ten minutes in a modern plant.

Wool drying.—Next the wool is conveyed to a drying machine. In this machine the wool is moved backwards and forwards and tumbled in all directions, while at the same time currents of dry, warm air are forced through it. In the recent, improved types of machinery, this entire process takes only about five minutes.

Some moisture left in the wool.—The wool is not even now absolutely dry. It is allowed to retain a certain percentage of moisture for the reason that it works better in this condition than if it were bone dry. When too dry, wool is brittle. On the other hand, left too wet, it will not go through the machines well, and lacks elasticity. The proper amount of moisture has been computed accurately, machines have been devised to test the wool as to its moisture, and still other machines to apply the proper amount. Such mechanisms are called conditioning machines. The amount of moisture considered best for the proper working of wool is about sixteen per cent of the total weight of the wool.

Burr picking.—After the wool is dried, it is generally passed through other machines that pick out the burrs and other large impurities which the sorting and washing could not or did not remove. Not only are the larger burrs and other foreign matters removed mechanically, but any dust or fine sand that may have come through is blown out and sifted out of the wool in these machines. In spite, however, of the best that all of these processes can do, some vegetable matter nearly always remains tangled up in the wool, and cannot be removed by hand or by means of machines. Much more of this may be found in one wool than in another, and the student can readily see that this difference

may be due largely to the differences in care given the sheep with regard to cleanliness.

Carbonizing.—The vegetable matter is removed by chemical means, a process called wool carbonizing. The method is comparatively simple. The wool to be carbonized is placed in tanks containing solutions of some strong acid like chloride of aluminum, hydrochloric, or sulphuric acid. Here it remains for a period of twelve hours, during which it is stirred several times. The acid, if it is not too strong, does not affect the woolen fibers, but attacks all vegetable matter and causes it to crumble. At the end of twelve hours the wool is taken out of the acid tanks and placed in an oven to dry. The temperature is raised to about 160° or 170° Fahrenheit, not so warm as seriously to harm the woolen fibers, but warm enough to cause the acid to eat or burn up the vegetable matter. When dried, the vegetable matter will be found reduced to a crisp and, on shaking the wool, will fall out easily in the form of dust. Even large burrs, straw, seeds, etc., can be removed in this way, but the risk in the use of acids and heat is such that the process is generally used only for disposing of the finer particles that the burr pickers and other machines cannot get at. The chemical carbonizing process came into use in the wool-manufacturing industry about 1880.

Loosening and oiling the wool.—After all of these cleaning processes the wool is run through another machine that takes the wool (which is now in mats and lumps) and picks it to pieces so that it all looks like a sheet of cotton batting; the same machine sprinkles a fine spray of olive oil or lard oil over the whole mass. This oiling causes the wool to work through the machines easily and prevents the fibers from flying about when the spinning and drawing begins. The lard oil is, of course, much cheaper than olive oil, but is not so cleanly and smooth in its effects on the wool; hence is used on the coarser, cheaper yarns. Lard oil is further-

more likely to turn rancid. After the oiling the wool fiber is ready for the carding machines.

Ripening.—When the wool has been oiled, some manufacturers, especially those who use the "class three" wools, the stiff, wiry carpet wools, roll it up in balls and let it "ripen" for a time, in some cases as long as two weeks. The oil meanwhile penetrates the fibers thoroughly, softens them, and makes them much easier to handle in the carding and spinning that follows. Other manufacturers send the wool directly from the oiling machines to the carding machines.

WOOLENS AND WORSTEDS

At this point the method of treating wool divides into two different processes, one for the making of woolens and the other for the making of worsteds. The main difference between woolens and worsteds is that woolens are made from yarns in which the fibers are crossed and intermixed in a more or less indefinite manner while in worsteds the fibers in the yarn have all been combed out so that they lie parallel to each other. It is easier to comb the longer wools; hence, in times past, before the modern improved combing machines were invented, the long varieties of wool were called combing wools, while the short varieties of wools were called carding wools, the kind used in making woolens. This distinction is no longer a practical one, for both classes of wool are now used in both the carding and combing operations. The only thing that the wool manufacturer considers now in choosing his wools is the price and the peculiar qualities that he desires in his finished cloth. The worsted manufacturer may find that he can get the short wools of the quality to make just the kind of worsted cloth he wants at a lower price than that of the long wools; naturally, then, since modern machines permit,

he will use the shorts. Usually, however, the fine long wools go into the manufacture of worsteds.

Mixing.—The processes that follow are somewhat similar to those found in cotton manufacturing, the main differences being in the styles of the machines, and their adjustments to the woolen fiber. Where there are to be several varieties or grades of wool used in making the same yarn, they are mixed in proper proportions in bins like those used for mixing cotton. For example, if three varieties or grades are to be used in certain proportions, the proper amount of each grade is weighed out and transferred to the bin where the mixing is to take place. The first grade is laid down evenly over the entire floor of the bin. Next the second grade is laid down in the same uniform manner, and finally the third grade; the entire mass is thereupon packed down thoroughly. When wool from this bin is wanted, it is removed by vertical sections including all wool from top to bottom, a process which secures the proper proportions of each grade in practically every armful.

Carding and spinning of woolen yarns.—Next the wool is fed into the hoppers of the carding machines. These hoppers are fitted with self-feeding devices that deliver the wool evenly to the carding cylinders. We need not describe these machines in any great detail. The wool is delivered from the cards in the form of a thin cotton-batting-like sheet very loose and filmy in texture and with the fibers running in every direction. The whole sheet is then shaped into narrow bands or ropes, called "slivers," and wound on large spools or bobbins. The bobbins are taken to the spinning room where the sliver is drawn out to the proper thickness and spun into yarn. The woolen yarn produced in this way is covered with a fuzz which is characteristic of woolens. Woolen yarns are usually spun on mule frames since these spinning machines leave the yarn

with a more fuzzy, oozy appearance and feeling than do the ring frames. The principle of wool spinning is the same as that of cotton spinning. The yarn comes from the spinning on paper cops, tubes, or bobbins. In this form it is ready for the weave room processes.

Sizes in woolen yarns.—The size of woolen yarn is determined in various ways in different places. There is no standard system of sizes or counts in woolen yarns as there is in cotton yarns. Two systems are common in this country, one known as the "American run counts" and the other the "Philadelphia counts." The American run of yarn is about 1,600 yards. This is taken as the base. If the yarn of that length weighs one pound it is called size 1. Yarn running 16,000 yards to the pound would be called 10's, and so on. Obviously, the coarser the yarn the lower the number of the run. A No. 1 or No. 2 run yarn is very coarse and would be used in overcoatings, blankets, and cotton warp goods, where all the weight was furnished by the filling. No. 3 and No. 4 yarns are medium, and Nos. 6½ to 10 are fine.

In the Philadelphia system the base is a "cut" which is 300 yards in length. When the yarn runs 3,000 yards to the pound, it is called No. 10 cut yarn. When it runs 9,000 yards to the pound it is called No. 30 cut yarn, and so on. A No. 5 cut yarn is very coarse; No. 18 to No. 20 cut yarns are medium; and No. 30 to No. 35 cut yarns are fine.

In Europe there are several systems such as the metric or international, the English, the Prussian, the Saxon, the Viennese, and the French. Each differs considerably from the others. We need not concern ourselves about these systems here.

Uses of woolen yarns.—Woolen yarns are used in making fabrics in which colors and figures are to be blended. Some of the ordinary woolens are broadcloth, flannel, blank-

etings, doeskin, beaver, cheviot, tweed, chinchilla, frieze, kersey, melton, and cassimeres.

The combing and carding processes for worsteds.—Wool that is to be made into worsted yarn is also carded, but with the result that the wool fibers are straightened out and made to lie generally parallel in direction rather than in the tangled form of the wool that comes from the woolen cards previously described. In this respect the cards used in making worsted yarn are more like those used in cotton manufacture than are the cards used in making woolen yarns; for in both cotton manufacture and the making of worsteds, the purpose of carding is to lay the fibers more regularly. What the carding machine does for the wool is not sufficient to make worsted yarn. Other fiber straightening processes must be employed. The wool is delivered from the carding machines in the form of a soft rope similar to that from the woolen cards described in the preceding paragraphs. This rope, called the "card sliver," is wound on wooden rolls into the shape of a large ball, or else is dropped into a tall metal can in such a way that it may be drawn out without difficulty or danger of tangling.

Gilling and combing.—In the form of card sliver, the wool is sent through gilling machines, several slivers at a time, and this process straightens the fibers of the wool a little more. From the gilling machine the wool comes off in soft strands. Four of these at a time are rolled up into a ball, and in this form the wool is taken to the combing machine proper. Eighteen of these balls are placed in the frame of the combing machine at one time. The ends of the slivers are properly attached to the combing apparatus and the machine started. Its operations are automatic. It needs but little attention except to replace the balls as soon as the first ones are exhausted, and to remove the combed wool which comes out in the form of a fine strand or sliver now called a *"top."*

The combing machine perfectly straightens out all the fibers, removes the short stock, the imperfect, knurly fibers, nibs, etc. This waste matter that comes out of the combing machine is called *"noils."* It can be used in various ways, as we shall see later on.

Combing machines.—There are four types of combs. The French or Heilman comb is suitable for combing the very short wools, especially those from South America. It is used extensively in France and is gaining in favor elsewhere for preparing soft yarns for dress goods. The square motion or Holden comb is adapted to wools of medium length but has not been widely adopted. The nip or Lister comb is used for combing the long varieties of wool, mohair, and alpaca. The comb most widely used, especially in the United States, because of its adaptability to average wools, is the Noble comb. This is really made up of three circular combs, two smaller ones revolving inside the larger and touching it at two points. Into the intersection of the circular combs, which all revolve in the same direction, the uncombed rope of wool is pressed by means of a brush. As the circles diverge, the wool, now imbedded in the teeth of the comb, is drawn through the teeth and left protruding from the inside of the large circle and from the outside of the small circles. The final operation collects these protruding ends and draws them off in a continuous and parallel rope or top. The short wool or noil, which is removed from the long fiber, is left in the small circles and from there removed by noil knives, falling as waste under the comb.

Gill boxes.—A number of the strands as they come from the combs are again combined and run through other machines called gill boxes. These reduce the strands to uniform size and again comb the yarn. The strands from the gill boxes are once more wound into large balls, and in this form are called "finished tops."

Combing is not always done by the mill that does the spinning and weaving. In fact some worsted goods manufacturers begin their processes with tops. The wool in this form may be purchased both in the markets and by contract with factories having combing machines. America both exports and imports large quantities of tops. England produces large quantities for Sweden, Germany, Italy, and Japan.

Drawing.—After the combing is completed, the tops are sent through drawing machines to reduce the size of the strand, and finally they are ready for twisting or spinning. It is then called "roving." It takes a variable number of machines to change the wool from tops to roving. Sometimes the strands pass through as many as eight or nine processes all tending to draw the strand a little finer. The finer the yarn that is to be made, the finer the roving must be, and therefore the more times the tops must be passed through the drawing machines.

Spinning.—In the last stages of the drawing a little twist is given to the roving to give it greater strength. Spinning consists in giving the yarn the full number of twists required. This number varies with the uses to which the yarn is to be put, and with the size. Yarns for clothing worsted average about fifteen turns to the inch in the finished yarns.

Spinning machines.—Worsted yarns are spun by two different sets of machines, one known as the Bradford system, named after the great worsted spinning center in England, and the other as the French system. The former is the older method and the one most frequently used in England and in certain parts of this country. The French system, however, seems to be supplanting the Bradford system. By this system it is possible to use the short wools in making worsted yarns. The French system also makes a fuzzier or more wooly yarn than the Bradford, and for many fabrics

this is very desirable. Again, French worsteds shrink less than the Bradford worsteds, another decided advantage. Still another is that the wool spun by the French system needs less oil. This is quite a saving, counting not only the oil but the soap that is required to wash the oil out after the yarn is made, and the time and labor it takes to perform the oiling and washing.

The difference between the French and the Bradford systems in technique is largely in the way the yarns are drawn out. The French system puts no twist in the yarn until it is fully drawn out for spinning. The openness of the fiber is preserved down to the last. The roving is then always spun on a mule frame and not on the cap or ring frame spinning machines. The product is a fine, soft, lofty yarn that is used for fine dress goods and fine knit goods. The Bradford yarns are more suitable for hard woven fabrics.

The cap-frame and the ring-frame spinning machines produce yarns the most rapidly. Since the cap-frame type is even more rapid than the ring-frame, it is best liked by the American producers of worsteds. The speed at which cap frames are run is so great that the yarn becomes somewhat rough because of the centrifugal force at the point where the yarn is wound on the spindle. For finer yarns the ring frame is used. For the finest yarns, as has already been stated, the mule frame is still the best spinning machine.

Worsted yarn sizes.—Worsted yarns are often twisted double or two-ply, and sometimes three- and four-ply. Single yarns are measured by a count system based on the hank of 560 yards. If there are 560 yards of yarn in a pound, the yarn is called No. 1 or simply 1's yarn; 32 times 560 yards in a pound would be called 32's yarn, and 60 times 560 yards in a pound would be called 60's yarn. This system of counts is found in both England and the United States. The low counts of yarns are used only for knit-

ting heavy sweaters; 30's to 40's are comparatively coarse for worsteds; 40's to 56's are medium; and 60's up to 100's are fine yarns. Good half-blood wool will make up into 60's worsted yarn. Counts above 80's are infrequent. When two 60's yarns are twisted together the yarn is designated as 2/60's and is read "two-sixties." In the same way there are 2/80's, 3/56's, 4/60's, and so on. A great deal of yarn is marketed in every spinning district, and quotations on the standard sizes may easily be found in any textile journal at any time. Considerable worsted yarn is used for ornamental needlework and knitting; among such yarns are Berlin wool, Zephyr, and Saxony. Much of the worsted yarn goes into knit goods and underwear, but the greatest portion goes into the manufacture of cloth for women's dresses and for men's suitings. The carpet wools are generally worked up into worsted yarns for the better grades of carpets and rugs; some good rugs are made from woolen yarns also.

Weaving.—The weaving processes for woolens and worsteds are so similar to those for cotton goods, already described, that there need be no repetition here. The products of the loom are either plain, twill, pile, double, or figured weaves.

Woolen fabrics.—Among the plain weaves in the woolens are the homespuns, broadcloths, kerseys, meltons, and others. Among twills in woolens are the doeskins, tweeds, cheviots, and cashmeres. The pile cloths, such as plushes and velvets, are generally made from worsted yarns, at least that portion that is used in producing the pile. Woolen double weaves include beavers, chinchillas, and like fabrics.

Worsted fabrics.—Worsteds are made up into all kinds of weaves used in the manufacture of cloth, though some form of twill is most common, especially for the suitings into which large amounts of worsteds are made. Examples

are the clay and unfinished worsteds, serges, woolen Bedford cords, whipcords, diagonals, Venetian cloths, wool crepes, panamas, etc.

Mixing wool with other textiles.—Both woolens and worsteds are often cheapened by the addition of cotton in various proportions. Wool is sometimes mixed with silk in various proportions in the production of fancy goods. Such mixtures of different textiles, cotton and wool, wool and silk, and the like, are known as union goods. Cotton is used in both the woolen and worsted cloth industries, almost entirely in the warp. Wool is used as the filling, as in cotton warp dress goods, cotton worsteds for men's wear, cotton warp blankets, and the like. To a certain extent, raw cotton is mixed with wool in producing "merino" or mixed yarns which are used in making certain cotton mixed woolen goods.

Cotton in knit goods.—In the knit goods lines the use of cotton has increased very rapidly during the last twenty years. This change has resulted because of at least four reasons:

1. Cotton is cheaper than wool, pound for pound, and yard for yard; hence is used as a matter of economy.
2. Cotton, with only slight mixtures of wool, can be made to appear like pure wool in knit goods; hence there has been much adulteration.
3. Changes and improvements in house heating systems have made unnecessary the old-time heavy flannels and all-wool underwear and hosiery. The cotton mixed goods are lighter and cooler than the all-wool goods.
4. Cotton mixed with wool produces a fabric that does not shrink as the old-time woolens did, hence in some ways is more desirable.

Before any of the fabrics produced by the looms or knitting machines are placed on the market, they must first re-

ceive certain finishing processes. These processes and their application will be taken up in later chapters.

Wool wastes or by-products.—In the production of wool from the raw material to the finished product a considerable number of so-called wastes occur. By-products would probably be a better name, for there are no wastes of material, strictly speaking, in a modern high-class woolen-manufacturing organization. Certain portions of the raw wool must be thrown aside when making certain classes of goods, but this raw material is used in making other goods. For example, at the very start of the manufacturing processes, as a result of the sorting, several different sizes of yarns are made from wool of the same fleece, and the parts not suited for making up into yarns are used in the manufacture of felt and padding.

Grease and potash.—In the washing process two by-products occur which are usually sufficient in quantity to pay for the washing. The grease in the sheep's wool is saved whenever it is removed by the petroleum-naphtha method. The refined product is called lanoline, a substance used as a base for medical salves and as a grease in soap making. In the ordinary wool-washing process, besides the grease, a considerable amount of potash is washed out. Potash in the wool comes from the perspiration of the sheep. It is said to be profitable to extract it from the water used in washing the wool. Potash has numerous uses running from medical preparations to fertilizer for land.

Soft waste.—But even when the proper variety of wool has been selected and the process of manufacture begun, naturally not every particle will go through into the finished product. A certain amount of fiber flies off in the carding operation and this, settling on the floors near by, is known as "carding waste." A considerable amount is rejected by the combing machines; this is called "noils." In the draw-

ing machines, certain portions of the tops are broken off or become entangled in the machinery. These pieces are removed by the machine tenders. If these pieces come from tops, they are called "top waste," and if from slubbing or roving, they are called "slubbing waste" or "roving waste." These wastes constitute what are known as "soft wastes," since they may be reclaimed directly by simply running them back into the carding machine along with the new wool.

Use of noils.—Noils, however, are not used in the manufacture of the same class of goods as those from which the noils are removed. Noils are generally taken from the worsted plants and sold to the carded woolen yarn producers. They form very important parts in the manufacture of woolens and knit goods, the recent census showing that nearly half of the raw material used in the manufacture of these goods was either noils from the worsted mills or shoddy.

Shoddy and garnet.—Shoddy is fiber manufactured by shredding woolen yarns and rags. The fiber from waste yarns is called "garnet." Both varieties taken together are called "hard waste" in contradistinction to the soft waste just described. The yarns that are shredded are the wastes, the ends, and tangled pieces from the spinning mills; and the rags include new pieces from the cutting tables of ready-made suit and cloak houses, tailor shops, and wherever there are cuttings from woolen fabrics; old scraps of cloth are also used, such as men's and women's wornout garments, suitings, coatings, sweaters, stockings, dress goods, and the like.

The rag business.—The old-rag business begins with the familiar country peddler or city pushcart man who gathers all kinds of old junk, among which there is a relatively small amount of woolen rags. At the end of his day's work, the peddler disposes of his heterogeneous collection to the small dealer in the town or city. The rags thus pur-

chased by the dealer are both cotton and wool. He first separates the cotton from the wool. The former he sells to the paper mills or to jobbers; the latter he sorts into three grades: 1. rough cloth; 2. skirted cloth; 3. soft woolens. Rough cloth is made up of street rags and other coarse and much-worn woolens, which are ground up and used in making felt paper and machine waste. Skirted cloth is the hard-woven fabrics, chiefly men's suitings and heavy coats. The term skirted refers to the tearing out of the linings. Soft woolens are made up of sweaters, stockings, hoods, soft dress goods known as merinos, and other soft and loosely woven fabrics.

The skirted cloth and soft woolens are sold to a larger dealer, who finally sorts the rags into hundreds of classes according to the demands of the shoddy trade. These rags, generally very dusty, are sorted as a rule by poorly paid women into the numerous sorts depending upon the quality, structure, composition, and color of the rags.

The business in new rags is also important. These rags are collected from the smaller tailor establishments and sweatshops and are sold as "mixed new clips" to the large dealer. The dealer also buys the cuttings from the large ready-made clothing establishments, where a great many clippings are wasted in cutting garments. New rags are smaller than old, and therefore the sorting of them is slower. Grades are made on the basis of quality, color, construction, and composition.

Shoddy grinding machines.—The rags after proper sorting are ground up in machines that loosen all of the fibers and tear them apart until the material is reduced to the consistency and structure of loose wool. This is then ready to be passed through the carding, drawing, and spinning operations in the same way as new wool. It is sometimes worked up into yarns by itself. Oftener it is mixed with new wool or with cotton. When made from a good quality

of rags shoddy may be of very good quality. In fact, good shoddy may be better in every way than poor new wool. Whatever the quality of the yarns or of the rags that go into the reducing machines, that will be the quality of the shoddy, except for one condition. The harder woven the fabric is, the harder it is to tear apart, and consequently more of the wool fibers will be torn to pieces. On account of this shortening of the fibers by tearing, the shoddy yarns cannot be as strong as the original yarns.

Mungo.—Mungo is a low-grade shoddy. It is usually made from the hardest woven woolen and worsted fabric. It has but little strength and is used mainly as a filler with other wools or with cotton. Most of it is used in the manufacture of blankets.

Flocks.—Flocks are the short fibers or nap shorn from the surface of woven fabrics in the finishing room. This substance is so short and fine that it looks like pulverized wool and is often so called. After the nap on a cloth has been raised it is finished off by shearing. The shearing machine acts like a lawn mower in cutting the raised nap; the short wool clipped off is known as flocks, used in the fulling process to give body and weight to cheap fabrics, and also for lining rubber coats and like articles.

Extract wool.—The wool in cotton-mixed goods is extracted by carbonizing, the same chemical process that we found used in freeing the raw wool from vegetable matter. The cotton-and-wool-mixed rags are soaked in an acid solution and then heated. This process burns out or carbonizes the vegetable matter, but damages the wool fiber very little. Later the cotton ash or dust is removed, whereupon the remaining wool is washed, dried, and ground up into loose fiber like other shoddy.

Uses of wool wastes.—In general, the waste wool products just enumerated are used in the carded woolen and knit goods industries. The noils obtained from combing

the long varieties of wool are frequently spun and made into cheviots. Sometimes these noils are mixed with short-wool noils or with cotton, sometimes with both. The short-wool noils are generally used in producing plain and fancy woolens or soft fabrics. They are sometimes mixed with cotton in making warp. Shoddies are used largely in fabrics of the cheviot class, tweeds, union goods, backing yarns, knit goods, and blankets. Only the best blankets are made entirely of new wool. All sorts of wool substitutes, shoddy, noils, wool waste, and cotton are extensively used in making ordinary blankets. It is a marvel to the uninitiated how the extremely short and poor wastes and shoddy can be spun into a yarn and finally into a cotton warp blanket. The very poorest wool wastes and extracts are put into horse blankets and into such hospital blankets as must be burned after use.

Effects of fashion.—Not only cheapness but fashion as well has a great deal to do with the output of products containing shoddy and other wool wastes. When fashion favors the kinds of fabrics in which shoddy can be used advantageously, the use of shoddy increases. Naturally shoddy can be used in woolens more readily than in worsteds, but during the last twenty years, worsteds have been rapidly gaining in public favor at the expense of woolen goods. At present worsteds consume about four times as much wool as woolens do in this country. But there have been brief fads in the use of rough-finished woolen goods such as cheviots, tweeds, cassimeres, and chinchillas. The demand for rough wool sweaters and other knit goods is also an opportunity for the use of noils, shoddy, wool extract, and other wool substitutes.

The place of shoddy among textiles.—The process of reclaiming wool from woolen rags, that is, the production of shoddy, was invented in England over a hundred years ago but did not come into great use until about fifty years

ago. There has been tremendous increase in the use of shoddy during the last few years, and it is likely that this is but the beginning of a much wider use. It is certain that as wool becomes higher in price, shoddy must supply the demand for warm, wool garments of a low and medium cost. In some lines, such as knit goods, the use of shoddy has superseded the use of new wool. It seems that some sort of regulation should be adopted to prevent the frequent injustice of selling shoddy for new wool, for it is very difficult and in some cases practically impossible to distinguish shoddy from new wool except in the wear. Dealers and consumers need to insist on getting what they pay for. Shoddy is all right at shoddy prices but not at the price of new high-grade wool.

CHAPTER XIV

THE GEOGRAPHY OF WOOL PRODUCTION

General facts.—The facts regarding the production of raw wool in this country, the number of sheep, and our imports of wool may be best described by means of a chart which was prepared by the U. S. Tariff Board in 1911; a copy of this chart is reproduced in this chapter.

In Figure 2 is shown the total wool production of all the sheep-raising countries in the world. Figure 3 shows the comparative number of sheep in each of these countries. It will be interesting to note that Russia has more sheep than either Argentina or the United States but that she produces less wool than either. New Zealand comes eighth in number of sheep, but fifth in amount of wool production. The student will recall that in the case of Russia a good deal of Class III wool, the poorest class, is produced, and that New Zealand produces a very high-grade merino and crossbred wool. Other interesting comparisons may be made from the same charts.

Figure 4 shows the relative wool production of the great wool-producing areas in the world. Figure 5 shows the production of wool in each state of the United States, and Figure 1 shows both the countries from which this country imports wool and the amounts imported from each, according to the three great classes of wool—short wools, long wools, and coarse carpet wools.

Primary wool markets.—The raw wool markets of the world are of two classes, primary wool markets and con-

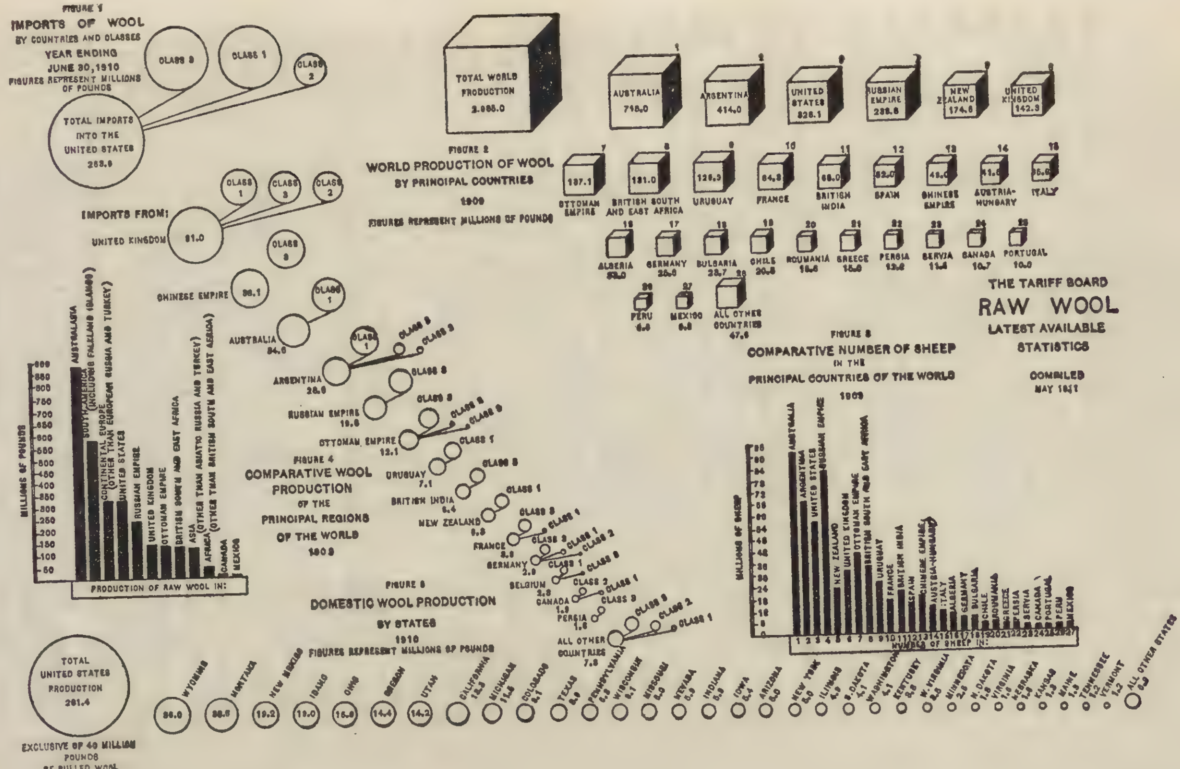


FIGURE 1
IMPORTS OF WOOL
BY COUNTRIES AND CLASSES
YEAR ENDING
JUNE 30, 1910
FIGURES REPRESENT MILLIONS OF POUNDS
TOTAL IMPORTS INTO THE UNITED STATES
IMPORTS FROM:
FIGURE 2
WORLD PRODUCTION OF WOOL
BY PRINCIPAL COUNTRIES
1909
FIGURES REPRESENT MILLIONS OF POUNDS
TOTAL WORLD PRODUCTION
THE TARIFF BOARD
RAW WOOL
LATEST AVAILABLE
STATISTICS
COMPILED
MAY 1911
FIGURE 3
COMPARATIVE NUMBER OF SHEEP
IN THE
PRINCIPAL COUNTRIES OF THE WORLD
1909
MILLIONS OF SHEEP
NUMBER OF SHEEP IN:
MILLIONS OF POUNDS
PRODUCTION OF RAW WOOL IN:
FIGURE 4
COMPARATIVE WOOL
PRODUCTION
OF THE
PRINCIPAL REGIONS
OF THE WORLD
1909
FIGURE 5
DOMESTIC WOOL PRODUCTION
BY STATES
1910
FIGURES REPRESENT MILLIONS OF POUNDS
TOTAL UNITED STATES PRODUCTION
281.4
EXCLUSIVE OF 40 MILLION POUNDS OF PULLED WOOL

centration points. First, there are primary markets where the wool changes hands from the grower to dealer or other buyer. These primary markets are numerous and widely scattered, especially in this country. There are a few places, however, which because of their location in the sheep-range country have become prominently known as primary markets. Among these are Billings, Big Timber, and Great Falls in Montana, and San Francisco, San Diego, and Portland on the Pacific Coast.

Concentration points.—More important still are the concentration points, where raw wool is handled in large quantities, bought and sold by dealers and manufacturers, exporters and importers. London is the greatest wool market in the world. Here wools from all over the world, particularly the finer grades, are brought and sold to buyers from all parts of England, the Continent, and even the United States. Sydney in New South Wales, Australia, comes second in quantity and value of wool handled.

The growth of Sydney as a wool market has been rapid during the last few years. Formerly it was a point of export for London and other European markets, but now buyers are coming to Sydney from all manufacturing countries, from England, Scotland, Germany, France, Belgium, Austria, Italy, Japan, and the United States. Sydney now markets more merino wool than even London. It is also a primary market for large numbers of sheep in New South Wales. Some of the wool warehouses found there cover six to eight acres and are from five to six floors high. Most of them are equipped with the most modern arrangements for baling, for storage, and for keeping the wool in the proper condition.

The other principal markets of Australia are Melbourne, Geelong, Adelaide, and Brisbane. Cape Town in South Africa, Buenos Aires in Argentina, and Montevideo in Uruguay are other highly important wool markets.

The carpet wools are first marketed in the countries where produced. Among the important points from which America and England get carpet wools are Constantinople, Bagdad, Aleppo, and Smyrna, all in Turkish dominions; Karachi and Bombay in India; Tientsin and Shanghai in China; Urga and Biisk in Mongolia; and Rostoff, Odessa, and Moscow in Russia.

The chief raw wool market in the United States is Boston. Philadelphia comes second, while Chicago and New York are also important.

Centralization of wool manufacturing.—Wool manufacturing is very widely distributed in one form or another. In only the modern, highly improved machine processes is a decided centralization of production found. A few of the more important wool goods producing centers of the world are considered here.

United States.—In worsted goods Massachusetts ranks first among the American states; then come Pennsylvania and Rhode Island. Lawrence, Massachusetts; Providence, Rhode Island; Philadelphia, Pennsylvania; and Cleveland, Ohio, are the noted worsted producing cities of the country. Pennsylvania has the largest number of woolen mills, but Massachusetts produces the greatest amount of woolen cloth. Woolen goods are more widely produced than are the worsteds. Carpet and rug weaving is practically confined to Pennsylvania, New York, and Massachusetts. Of hosiery and knit goods, New York produces the most; Pennsylvania ranks second; Massachusetts, Illinois, Ohio, and Wisconsin follow in the order given.

England.—In England nearly three-fourths of the woolen industries are found in the western part of Yorkshire in or near the city of Bradford. Bradford is important as a distributing center of raw materials, as the center of worsted combing and spinning, and as the center for the production of worsted stuffs or dress goods for women's wear. Hud-

dersfield is the center for the production of the best worsted goods for men's wear. Fancy cheap woolens made in imitation of Scotch tweeds are made in the Colne Valley near Huddersfield. Colne Valley woolens are known the world over as cheap materials. Heavy woolens, overcoatings, cheap cloakings, blankets, and army cloths are made in and near Dewsbury and Batley. This is the center of the shoddy and rag business, and much of the reclaimed wool, by skillful blending and manipulation, is turned into cheap but serviceable fabrics. Fabrics made at Morley are the lowest quality made. Leeds, once noted for its broadcloths, has now taken up the manufacture of worsted coatings, serges, etc. Halifax is best known as a producer of worsted yarn. Rochdale in Lancashire is important for its flannels, Stroud in western England has the reputation of making the finest woolens in the world. Kidderminster is the most important carpet center; while Leicester, parts of Nottingham, and Derby are important in the production of hosiery.

Scotland.—In Scotland the manufacture of Scotch tweeds is an important industry, Galashiels being the most important center.

Germany.—Wool manufactories are found all over the German Empire. There is no such single important center as Bradford, England; furthermore the various localities each produce both woolens and worsteds. Some of the greatest manufacturing cities are Blumenthal, Hamburg, Leipzig, Dohren, Mylau, Plauen, Muhlhausen, Gera, Aachen, Breslau, and Forst. Among the nations, Germany is the third greatest producer of woolen goods in the world.

France.—In France, the Department of the North, which borders on Belgium, is the most important wool-manufacturing center. Nearly all the combing is done here, and most of the spinning and weaving as well. Roubaix is the chief city in the business. In a way its leadership is com-

parable to that of Bradford, England, but, of course, on a smaller scale. Tourcoing and Fourmies, other towns in the same department, are also important. The town of Elbœuf in Normandy compares with Leeds in England in the manufacture of worsteds. It does a miscellaneous business in both woolens and worsteds. Vienne on the Rhone River is the center of shoddy cloth manufacture, and the manufacture of blankets is largely confined to the surrounding towns. Mazamet does a remarkable business in the production of pulled wools from South American and Cape sheep skins. Wool velvets are produced in the Department of Somme and plushes in the Department of Aisne.

CHAPTER XV

MOHAIR, ITS NATURE AND USES

Sources of Mohair.—There are three principal sources of mohair in the world: Turkey, South Africa, and the United States. According to the most reliable information available, there are in Turkey in the region about Angora where the breed of Angora goats originated, approximately 1,200,000 of these goats. In all Africa, but mostly in the Cape Province of the South African Union, there are about 3,585,000 Angoras, with about 5,000,000 goats of the common breeds.

Unfortunately for the preservation of the pure Angora blood, the Turks many years ago began to cross their flocks with the common "Kurd" goats, which resulted in so great an infusion of inferior blood that today all goat raisers agree that there are no pure-blood Angoras left, those now used all being more or less contaminated with the common blood. To conserve its flocks and to preserve to the Turkish people the Angoras in their purest state, the Turkish government some years ago prohibited the exportation of Angoras.

The American Angora raiser has, therefore, but the one source for obtaining new blood to build up the flocks in this country—South Africa; but, fortunately, before the Turkish embargo was passed, some of the best of the Turkish goats had been exported to the United States and also to South Africa, so that in all probability, due to the more intelligent interest taken by the Angora raisers in these

countries, it is not likely that much better blood can be procured in Angora itself than can be found in either South Africa or the United States.

Mohair and its uses.—As stated before, in 1910 the American mills used almost 5,000,000 pounds of mohair, about two-thirds of which was of American raising.

Comparing the imported hair with the domestic, manufacturers agree that the domestic lacks brightness and luster and does not spin so well as the Turkish hair. Owing to certain climatic conditions, especially in the Southwest, it is necessary to shear the goats twice a year, which of course results in a much shorter staple, whereas the foreign goats are generally shorn but once a year. Every effort is made to grow as long a staple as possible; in Oregon and in some parts of California, where the goats are sheared but once a year, the production of hair between fifteen and twenty inches in length is not unusual in flocks where the grade has been kept to the highest possible standard. For the United States as a whole, where the fleece is allowed to grow an entire year, the average length is about ten inches.

The following articles are made from mohair: plushes used for railway cars and upholstering furniture, coat linings, dress goods, men's summer suits, automobile tops, braids, rugs, and carriage robes, imitation furs for women's and children's wear, couch and table covers, portieres; false hair from crimped and curved mohair. The skins tanned with the hair on are used extensively for carriage robes, muffs, and trimmings for coats and capes.

The market for mohair is unusually dependent upon the caprices of fashion; let there be a change in fashion's edict and there may be a great demand for mohair; a remarkable falling off is no less likely to occur at any moment.

Considering the amount of domestic hair now being used by the American mills, it is apparent that the future of

Angora goat-raising industry lies in improving rather than increasing the output of mohair. The American people must also be educated to the eating of "Angora mutton." Most mohair experts agree that when proper care and attention are given, American mohair equals the best South African or Turkish product.

Quality of the hair.—The manufacturers state that the production of domestic hair has improved greatly during the last few years, both in staple and in freedom from kemp or dead hairs. In using the domestic and imported hair the manufacturers usually blend the imported in such a proportion as to enable them to use the mixture in most of their products.

As the goat grows older, the fiber of the hair becomes straighter and thicker and loses its curly quality as well as its luster; hence the best hair comes from the kids, young wethers, and young does.

The highest grade of mohair should hang in curly ringlets from all parts of the animal's body. The mohair manufacturers prefer hair not less than six inches in length, one of the most prominent stating that he could use very little of the Southwestern hair on account of its being too short. Some Texas flocks were investigated where the growers had produced fleeces from fifteen to twenty-two inches long; such fleeces were sold for special purposes, bringing very high prices.

The majority of the manufacturers purchase a large percentage of their hair direct from the growers in person, or from selling agencies established by the Angora Goat Association in the West.

The great effort of the Angora raisers of today is to develop a goat that will shear a long, lustrous, curly fleece of fine character and free from the obnoxious "kemp." Kemp is the long, coarse hair which, with very few exceptions, is found in some quantity on even the best An-

goras. It is believed to be a last reminder of the common blood bred into the original herds in Turkey; in the judgment of some of the best growers it will never be completely eradicated. Kemp is objectionable in that it will not take any of the dyes used in dying mohair; for this reason the manufactured goods are defective whenever the kemp is used. Kemp can readily be discovered in a fleece as it lacks the luster or sheen of the true mohair, being a dead, chalky white and coarser than the rest of the fleece.

The average shearing value of the American Angora is not so high as it probably might be, because of the mixture of common blood in many of the flocks. The average goat of higher class flocks shears a trifle over three and one-half pounds, but taking the country over, the average is probably somewhat under two and one-half pounds. A high shearing average is not altogether an evidence of superior mohair. According to the best authority available the average for the Turkish Angora is but two and three-fourths pounds a goat, while that for those of South Africa is above three and one-half pounds each.

Handling goats on range.—In general, the goats are handled much the same as the sheep, save that the constant presence of the herder is not necessary. Many goatherds turn the animals out of the pens in the early morning, sending a dog with them to keep away wild animals. During the day the herder rides out to the herd once or twice to note the direction in which they are feeding. Usually if they are allowed to graze alone, the goats will travel too fast and cover too much country, which is injurious to the range as well as to the animals. Careful herders remain with their goats and check this tendency to travel.

The necessary equipment for raising goats is somewhat similar to that for sheep raising. It is especially necessary that proper sheds should be furnished to shelter the goats during wet weather, as they are very susceptible to moisture.

Contrary to general belief, no domestic animal is more fastidious as to its food than the Angora. When fed hay or other artificial food, every care must be taken to keep the food away from the mud and dirt; Angoras will refuse to touch any food which is soiled or trampled into the ground. Muddy or foul drinking water will not answer, and fresh water must be furnished if these animals are to do well either on the range or in feed lots.

Angoras will always endeavor to find shelter from approaching storm and must have sheds under which to creep during stormy weather. As long as it is clear and cold, or the snow is dry, they are comfortable and remain out; but their long, open fleece is soon soaked in the rain, and is seriously affected by the moisture on their bodies.

Angoras require plenty of air and light, and all sheds provided must be open as much as is compatible with keeping out rain or snow. The pens should never become muddy, for the long, silky fleece will easily pick up a great weight of mud, which not only burdens the animal but stains and injures the fleece as well.

Contrary to the general idea, the raising of Angora goats is rather difficult. The young are more delicate than lambs, and their mortality is greater, especially among the well-bred animals. Incessant personal care is absolutely necessary in raising the kids until they are about two months old. The methods of raising the kids are many, especially during their early weeks, when it is inadvisable to let them follow the doe out upon the ranges.

The browsing habit of the goats renders them available even on land where other domestic animals would not find sufficient feed. Goats relish and thrive on all manner of browses; on leaves, shrubs, and small trees, and on moderate amounts of weeds and grass. Despite the general opinion, goats will not do well on brush alone, although a large part of their food is browse. Because of their liking for brows-

ing, goats are occasionally introduced into many states solely for the purpose of clearing the land of brush and bringing it into pasturage. This same browsing habit has caused their exclusion from many parts of the national forests throughout the West, and from watersheds where it is desirable to protect the brushy cover in order to prevent erosion and the filling up by silt of the reservoirs for water supply.

The land upon which goats thrive best being generally useless for other domestic animals, its actual or rental value is generally much below that of pasture land for sheep or cattle, although on the various national forests practically the same fees are charged for goats as for sheep. The total average yearly cost for grazing for one goat is about the same as that for one sheep in the same region, or sometimes a little less. This statement refers, of course, to range-raised goats and not to those raised in small flocks upon farms or within small pastures.

Receipts from raising Angora goats.—The average receipts from mohair are approximately $1.02 for each goat. Owing to the varying conditions under which the mutton is sold it is impossible to compute any averages from that source which would be applicable to the entire goat-raising region.

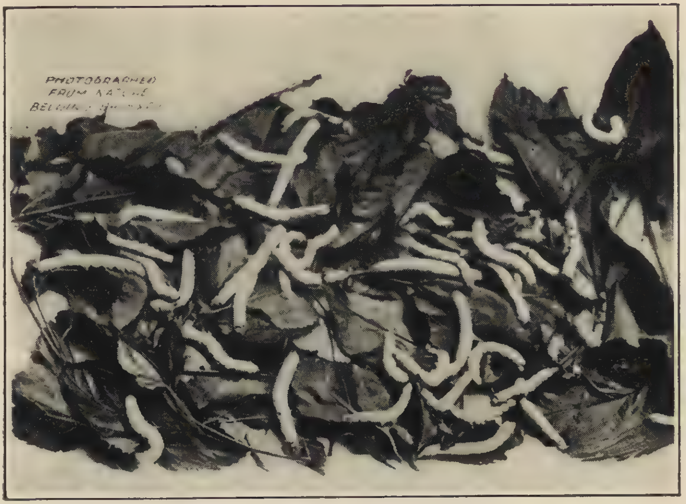
CHAPTER XVI

RAW SILK PRODUCTION

THE SILKWORM OR MOTH

Silk is produced from cocoons of an insect usually and rather inaccurately called the "silkworm." This popular name originates from the fact that the silk-producing moth, before reaching maturity, passes through a caterpillar or worm stage during which it spins for itself the cocoon from which later it emerges as a true moth, closely related in nature to the butterfly. The cocoon, formed from an unbroken fiber secreted from the caterpillar's body, is gathered and the fiber unwound, thereby furnishing the silk fiber of commerce.

Varieties of silk moths.—There are between three and four hundred varieties of moths that produce silk cocoons, many of these varieties being found in America. Only a few produce cocoons of the kind and quantity that make it profitable to collect them. Most silk comes from a single variety known to science as the *Bombyx mori.* This silk moth, or silkworm as we shall call it, has been raised for hundreds and even thousands of years. It is correctly called the domesticated silkworm. From just what wild variety it originally came is not known. It has probably changed greatly during its age-long process of culture. By the selection of only the larger ones for breeding purposes, this variety has been increased in size, with consequent enlargement of the cocoon. It has lost its power of flight.



SILKWORM CULTURE.

RAW SILK BUNDLED AND BALED.

The wings of the full-grown moth are practically useless. At the caterpillar stage it has lost its sight. The constant care that man has given to thousands of generations of worms has made it unnecessary for them to see or fly; these functions therefore have been lost. All necessary movements are provided for by human attendants, who carry the worms to the feeding places and supply them with food. The *Bombyx mori,* the domestic silkworm, is white or cream-colored, whereas the wild varieties vary widely in color. Brown is very common.

Stages in the life of a silkworm.—The silkworms of all varieties pass through four marked stages: first we find them as eggs; second, as caterpillars or worms; third, as chrysalides, inside of the cocoons; and fourth, as full-grown moths. It takes from twenty to thirty days for the eggs to hatch. The caterpillar stage lasts about 30 days. The chrysalis stage lasts but a few days, and the moths die as soon as they have mated and laid the new generation of eggs.

The *Bombyx mori* produces but one new generation each year. For this reason it is called *univoltine.* Some of the wild species of silkworms, however, annually produce two, three, and even more generations. The common Chinese wild silkworms produce as many as seven crops each year in the Hongkong district, while a variety in Bengal, India, produces eight generations. These varieties are called *multivoltine.* The univoltine is preferred for cultivation to the many multivoltine species because it produces the finest and strongest silk. In the attempt to use the cocoons from the multivoltine species there is a great deal of waste; it is utterly impossible to reel the cocoons of some varieties.

The Egg.—Silkworm eggs are about the size of a turnip-seed and it takes from 30,000 to 40,000 to weigh an ounce. If all goes well, these will produce about 130 to 140 pounds of cocoons, and from these about twelve pounds of raw silk may be reeled. Eggs are sometimes sold by one grower to

another for so much an ounce. When first laid they are yellow, but if fertile they soon turn blue-gray. The univoltine species is hatched in the month of June by the use of incubators in which the temperature is kept at about 75 degrees. In Oriental countries the eggs are sometimes kept at the required temperature by having them wrapped in folds of cloth around the bodies of the people who are caring for the silk-raising establishments.

The Worms or Caterpillars.—Finally the eggs hatch and little, dark-colored worms creep out. This is the caterpillar or larva stage. These little baby caterpillars, especially of the domestic species, are almost helpless. Those in charge provide mulberry leaves to the under side of which the caterpillars attach themselves and get food by sucking the juice out of the leaf. In eight days they have attained considerable growth and are ready to shed their skins for the first time. Three other moltings take place before the caterpillar is full grown. Each time, as the molting period approaches, the worms stop eating, rise on their hind legs, and remain still for a couple of days. Finally a crack starts in the skin above the nose. This enlarges until it gives room for the head and later for the body to wriggle out. As soon as the skin is shed the caterpillar becomes voraciously hungry and avidly attacks the leaves supplied to it. After the first few days of caterpillar life, the worms cease sucking and begin to eat the entire soft parts of the leaf by cutting out pieces and devouring them. The noise made by thousands of these worms in a room, all busily feeding, is like that of falling rain.

Care of the caterpillars.—The worms are kept on shallow trays which are placed by the dozen in frames. Laborers—men, women, and children—busily pick leaves from the trees, bring them in fresh to the worms, change the worms from tray to tray, clean the old trays and prepare them for another group of worms. Great care is necessary in so

handling the worms that they may not be hurt. Though the worms are blind, they have none the less a very acute hearing; wherefore all noises must be prevented so far as is possible. A sharp noise causes the worm to stop feeding and to give out—really to waste—a part of that liquid in its body which will later make silk fiber. Much silk is lost in this way, even when the utmost care is exercised. Such unavoidable noises as thunderstorms cause very marked losses. As a rule the laborers walk barefooted or in their stocking feet about the room in which the silkworms are kept.

The Cocoon.—After the caterpillar has shed its skin four times it is ready to pass into the next stage, that of the cocoon or chrysalis. One ounce of eggs has become by this time, if good fortune has attended the work, 20,000 full-grown worms. These worms have consumed in the period of thirty days over half a ton of green leaves. When ready to spin their cocoons, the worms are transferred to trays constructed with brushy tufts in which they like to make their cocoons.

The cocoon is constructed in most interesting fashion. There are two long bags inside the worm's body, one along each side. These bags or sacs contain a sticky or viscous liquid. This is slowly exuded through the worm's under lip, and immediately upon coming into the air it hardens into a thin little stream of fiber; this fiber is the silk. Usually both bags exude the liquid at the same time; hence the fiber that is formed at the lower lip of the worm is generally double, as can be seen by laying almost any silk fiber under a strong magnifying glass or a microscope.

The worm attaches itself to a tuft on the tray provided for it. The wild worm selects some bush, weed, tuft, or grass, where it begins to give off the silk liquid, and, as it does so, swings its head from one side to the other, depositing the silk fiber in the form of figure eights. At first the

directions are somewhat irregular, but later the method of laying the fiber becomes almost uniform. Soon the worm is wholly inclosed by his tent of silk fiber, but he continues spinning on the inside until his silk secretions are used up, and the cocoon is completed.

The Chrysalis.—The caterpillar then changes from a worm to a chrysalis, a thing that looks partly like a worm and partly like an insect. In this condition it sleeps for about eighteen to twenty days. Then, if left undisturbed, it is transformed into a moth; it becomes fully awake, and strives to emerge from the cocoon. Slowly it pushes itself forward against the wall of the cocoon, breaking some of the obstructing fiber and dissolving parts of it by a strong, alkaline liquid which it gives out of its mouth.

The Moth.—After it has come out of the cocoon the moth remains quiet until its wings are dry, and then proceeds to the mating which lasts for several hours. The female moth now lays her eggs in two deposits, a few hours apart. Each moth produces from three hundred to five hundred eggs. The male is smaller than the female, but more active. Both are covered with woolly hair and, if of the *Bombyx mori* variety, are creamy white in color. Neither male nor female eats anything betwen the time when it begins to spin and its death.

Completing the Cycle of Life.—The eggs are laid over an even surface, sometimes with a gummy liquid that sticks the eggs to the object upon which they are laid. Shortly after the mating and the laying of the eggs, the moth dies. Its cycle of life is completed.

HOW THE SILK FIBER IS OBTAINED

As already indicated the cocoons are the source of the silk fiber. The silkworm deposits upwards of 4,000 yards

of the tiny fiber in making its cocoon. But when the moth leaves the cocoon by breaking its way out, it cuts this fiber off in many places, thus largely decreasing its value; hence silk producers kill the chrysalis in the cocoon to prevent its coming through. The usual method is that of immersing the cocoons in steam for a few minutes. Sometimes the chrysalides are killed by baking the cocoons in a hot oven; recently a method of freezing them to death has been used to a limited extent. Another method, that of placing the cocoons in boiling water, serves a double purpose. Not only does it kill the chrysalides, but it also softens the "gum" that sticks the threads together, so that they can be unreeled from the cocoon. But in this case the reeling must begin at once, while if the chrysalides are killed by steam, heat, or frost, the cocoons may be kept in their original form for years.

The cocoons of the best domesticated varieties of silkworms are either white or cream-colored. The wild cocoons may have almost any color, according to the feed upon which the caterpillar lives. It has been shown that red coloring matter put into mulberry leaves fed to the worms tends to tint the cocoon red, and that other colors put into their food produce corresponding effects in the cocoons.

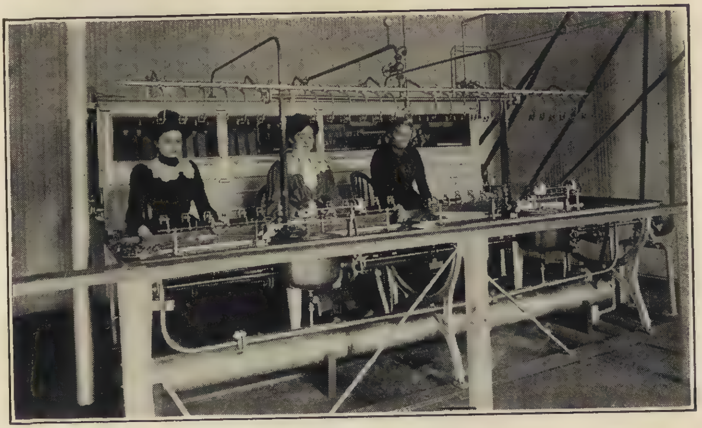
Reeling.—The fiber is removed from the whole cocoons by a process of unreeling. The method is as simple as it is laborious. After the fiber in the cocoon is loosened by soaking in boiling water, the cocoons are taken out, and the floss, or loose, fluffy, silky fiber on the outside, is cleaned off to be used in the production of carded silk yarns. Next the cocoons are put into a basin containing water kept constantly at lukewarm temperature. Laborers use a whisk broom or brush and push the cocoons up and down in the water until some loose end of fiber becomes attached to the broom. This fiber, the loose end of a cocoon, is drawn

gently; the cocoon tumbles around in the water and gradually it unreels itself. A single fiber is very small, and for reeling purposes usually three or four are combined. These are passed through a smooth ring as one fiber and then onto a reel frame which is usually run by foot power, but sometimes by mechanical power in modern reeling plants, or by filatures as they are called. By means of the reel frames the raw silk is reeled into skeins or hanks.

Care necessary in reeling.—The threads as they come from the cocoons are not of even thickness because of the fact that the various glands in the spinning worm do not operate alike at all times. Most of the time both glands or silk sacs secrete together, but occasionally only one produces; hence unevenness results. As a rule the thread is finer when the worm first begins to spin than it is during the middle of the process; the fiber tapers again at the end of the spinning. Since it is very necessary to get an even silk thread in the skein that is being formed, the operator in charge must be constantly on the watch. When the thread grows thin, another is added; when it grows thick a thread or two is taken out. Each operator runs two reels. Keeping both reels going and carefully watching the threads to note changes in size, adding to or taking away to give uniform size, preventing breakage, and keeping a new supply of cocoons properly soaked in the basin—all these are duties that call for extreme deftness of fingers, accuracy of eye, and quickness of mind.

Product per cocoon.—The average cocoon reels off about three hundred yards in a single thread. It will be recalled that there may be as many as 4,000 yards in a cocoon, but considerable is brushed off in the outer floss, and a portion near the inside will not reel well; hence only the middle of the fiber can be saved in the form of one long thread. The very best cocoons reel off as high as four hundred yards.

Cocoon wastes.—The portions that are not reeled are



Reel in operation.

Reeled and waste silk.

used in making coarser yarns by carding, combing, and spinning as with the other textiles. The longer fibers are often carded and combed as in making worsteds. This sort of silk is known as *florette* silk. Shorter fibers which may only be carded and then spun are called *bourette* silk. The general names for both varieties are silk waste, floss, schappe, or echappe. Floss is probably the best name, since schappe is used frequently for manufactured goods made out of floss or waste. But it should be remembered that floss is also the name given to the outside loose fibers surrounding the cocoon.

Breeding silk moths.—The cocoons are not all alike in size, shape, color, and other qualities. For example, the cocoons containing female chrysalides are larger than those containing males. The color varies considerably. Not all can be used for making silk fiber; some must be left for breeding purposes. The very largest, best-looking, smoothest, and healthiest are set aside and the moths allowed to come out and breed. This method makes sure that the stock of silkworms will be kept up to a high producing standard.

Sorting Cocoons.—The very best cocoons are often set aside and reeled by themselves for the finest and strongest silk threads. For example, silk warp is usually made from fiber drawn from the better grades of cocoons. The finest sewing silk comes from the most perfect cocoons. The poorest cocoons, the deformed, discolored, or otherwise defective ones, are often not reeled at all but are simply turned at once into silk floss.

Silk wastes.—Various names are given to the grades and kinds of waste or floss silk. Very irregular masses of torn silk fibers are called *watt* silk. The inner portions of the cocoon next to the chrysalis are called *wadding, neri,* or *ricotti,* and various other names. Imperfect cocoons which are not reeled are called *cocoons* or *piques.* The wastes

accumulated in reeling, due to breakage, loose ends, and so on, are called *frissonets.*

USE OF SILK WASTE.—Until about 1857, silk waste was entirely useless, but it is now the material of an important industry. It is cleared of gum by boiling, and then run through machines that break up, card, comb, and draw the fibers into shape for spinning.

Silkworm diseases.—The silkworm is subject to a number of severe diseases, and also to depredations from mice, weevils, and ants. There are times when whole chambers where the silkworms are kept become infected with contagious diseases that kill off the worms before they can spin. Wild worms are by no means so liable to disease. The susceptibility to disease is a direct result of domestication. Under the most favorable circumstances, fully one-fourth of the eggs fail to produce worms that grow to maturity. Some are killed by accident, but the majority by disease.

The principal diseases of the silkworm are: pebrine, grasserie, flacherie (or flaccidity), gattine (or macilonza), and muscardine (or calcino).

Pebrine is a bacterial disease, both hereditary and contagious, which has wrought tremendous damage in the silk industry in Europe, especially in France. At one time, about 1865, the French cocoon production had been almost destroyed. No cure for the disease has ever been discovered. The only means of getting rid of it is to allow the affected worms and moths to die out, carefully to disinfect the premises, and then to start in with a fresh supply of healthy eggs.

SCIENCE IN TREATING SILKWORM DISEASES.—Pasteur, a noted French scientist, showed how the disease might be prevented. Every moth, after laying its eggs, is killed and its interior examined carefully under a microscope, the only means of discovering the germs. If the germs are found in the moth's body, the eggs are destroyed, since they also

are sure to contain some germs carried from the mother moth's body. When no signs of germs are found in the moth, the eggs are considered safe to grow. After this method came into use, French silk growing leaped forward again. Experiment stations for the examination of eggs were established by the government in numerous places—an example followed by Italy and other countries. Lately the French growers have become careless again, and silk production is consequently rapidly falling off. Now, Italy and Austria are doing the most to stamp out the disease, and these two countries are producing the finest raw silks. Particularly in Tyrol, a province in Austria, is this scientific method of propagating disease-free eggs in most successful use. No silk-growing peasant in either Italy or Tyrol would today think of hatching out silkworm eggs that were not certified by some government experiment station as free from disease. Leading growers in France are hoping to revive the careful inspection that Pasteur planned for them.

Flacherie is now the most dreaded disease among European silkworm growers. It attacks and speedily kills the worms shortly before they are full-grown. Often thousands of worms in one room die in a single day. It is really a form of indigestion due to various causes such as overeating, poor leaves, bad air in the room, excessive heat, dust on the leaves, or keeping worms too thick on the trays. Like pebrine, flacherie is contagious and hereditary. It can, however, be prevented by carefully avoiding the causes mentioned, and by disinfecting the rooms where cases have occurred. Eggs that have been exposed to the disease are washed in a disinfecting solution before being hatched.

The worms may easily be overfed at certain stages, especially on young, tender leaves when the worms are almost full-grown. Sometimes, this overfeeding causes a disease that is called grasserie. It is not contagious, but does kill

a number of worms every year, especially in warm countries.

Gattine causes the worms to become torpid. This is a germ disease, and can be eradicated by changing the trays and disinfecting the old ones. The growers sometimes shake the worms vigorously and thus jar them out of their torpor.

Muscardine is a mold disease which kills worms very rapidly whenever it gets a start. It is more contagious than any other silkworm disease. The methods of getting rid of it are disinfection, letting in pure air and light into the trays, burning sulphur in the room, and so on.

The possibility of disease, together with the constant need of care, keeps the silk growers constantly on the watch over their worms. The task is tremendous, and the chances for loss are always great.

WILD SILKS

The wild silks are gathered principally in Japan, China, and India. There are, of course, several varieties of wild silk cocoons, each with qualities somewhat different from the rest. The principal variety of Japan is the *Yamai-mai*, and the chief varieties of India are the tusser, or tussah, and the ailanthus. As already indicated, most of these silks are much darker in color than the domesticated silk, the *Bombyx mori*, probably because of the difference in feed. Wild silkworms do not always have mulberry leaves to eat. Great numbers feed on oak leaves and in some cases on other plants.

Quality of wild silk.—In a general way it may be said that wild silks are in most respects of poorer quality than domesticated silk. They are harder to bleach, and do not take dyes so well. They are generally very uneven in texture, but when made up into fabrics are often more durable

than common silks. Wild silks are used principally in the manufacture of pile fabrics such as velvet, plush, and imitation sealskin, and in heavy or rough cloths such as pongees and shantungs. While the silkworms of the wild varieties take care of themselves, and therefore do not require the constant labor that must be given to domesticated silk, the expense of gathering is nevertheless high. The wild cocoons must be hunted, trees must be climbed to gather them, and much time may be consumed in collecting comparatively few. On the whole, however, because of the poorer qualities, wild silks are worth considerably less than "tame" silks.

NATURE OF SILK FIBER

The perfect raw silk fiber is a very fine filament with two parts that can readily be seen under a microscope. This filament is composed of a substance called *fibroin,* and the outside is covered with a waxy substance called *sericin.* Silk fiber in its raw state is for its size the strongest textile fiber in existence. It is said that it is as strong as an iron wire of the same size would be. Notwithstanding that in the processes of manufacture much of this strength is lost, unless very badly treated, the fiber remains remarkably strong. It is also very elastic and durable. It has a high natural luster which is improved upon in some manufacturing processes. The fabrics into which it is made are beautiful even in the natural silk colors.

Absorptive power of silk.—Silk fiber readily absorbs water; wherefore, in commerce, rules are necessary regarding the amount of water allowable in the fiber offered for sale. The usual amount allowed by weight is about eleven per cent. It can easily be understood that when raw silk fiber sells for more than three dollars a pound, a large fraction of the total weight, such as one-third, one-fourth,

one-fifth, or even one-tenth of water, would make a big difference in the price. Silk markets, therefore, are always equipped with the necessary apparatus for telling just what part of the weight of the silk is water. For example, the Silk Association of America has a large laboratory in New York in which the principal work is the determination of the proportion of moisture in raw silks brought from the market. The process of getting the silk into the proper standard condition as regards moisture is called "silk conditioning."

Because of its absorptive qualities, silk takes dyes very well, in fact better than any other textile; hence silks may be given delicate shades and tints of color that would be quite impossible in cotton or linen. It may also, as we shall see, absorb weighting materials that are introduced by way of adulteration. Pure dye silk should not contain more than ten per cent of its weight in dyeing or weighting materials. Ordinary silks contain much more weighting than this.

HUMAN LABOR IN SILK PRODUCTION

After the raw silk has been reeled into skeins or hanks, the most laborious parts of silk production are completed; that is, most of the work done on the fiber thereafter is done by machine processes instead of by hand. The amount of hand labor that it takes to produce raw silk is almost incredible, and the amount of labor taken after the machine processes begin is no less than for other textiles. It has been said that it takes more human labor to produce a lady's silk dress, from the mulberry leaves into the finished product ready for wear, than it takes to produce and build a locomotive out of the raw ores in the ground. More hours are expended, and more people have something to do with the work.

Cost of production.—If the labor employed in the production of silk were paid as high wages as are commonly paid in the iron and steel industry the silk dress would cost almost as much as a locomotive. As it is, raw silk production is carried on chiefly in countries where wages are very low. At the present prices of silk, the most efficient workmen doing their very best could not earn more than fifteen cents per day at this kind of work. The usual wages in the silk-producing countries are lower than this.

Where the raw silk is produced.—It is not surprising then that 40 per cent of the world's raw silk is produced by the Empire of China, 20 per cent by Japan, 20 per cent by Italy, 10 per cent by Persia, Asiatic Turkey, India, and Arabia, and the remaining 10 per cent by France, Austria, Spain, or Portugal. Italy produces some of the finest silk in the world; India and China, some of the coarsest and poorest.

Attempts to raise silk in the United States.—Several attempts have been made to raise silk in this country, and practically every experiment has shown that a very fine quality of fiber could be produced; but the great obstacle is the cost of labor to care for the worms, pick the leaves, attend to the mating of the moths, make the necessary examinations for disease, and reel the raw silk. No mechanical devices have ever been invented to do away with the great amount of human hand labor. Not while clever people, men, women, and children, in China, Japan, and other countries are willing to work for less than ten cents a day as they now do, can raw silk production become profitable in this country.

Methods of production in Japan.—Silk is often handled as an auxiliary industry by Japanese and Chinese farmers. The women and children are occupied with the care of the silkworms while the adult men are employed in the gardens and fields. Being a home industry of this nature, it

is often undertaken even when there is small prospect for payment for time expended. The time of the women and children is not considered worth much in any case. One person cares for about 10,000 to 12,000 worms. The average production per family among the families that do raise silk is about five bushels of cocoons per year. The return for these cocoons generally pays for the labor expended in their production at about the rate of ten cents a day.

Improvements in reeling silk.—Reeling has been greatly improved in modern filatures by the introduction of power for running the reels and by using gas to keep the basins heated at a proper and constant temperature, but this change has not eliminated the necessity for cheap labor. No filature of any consequence is to be found in any country or city except where labor is abundant and very cheap. Silk reeled by hand or foot power is called "re-reel silk," while that reeled by power machinery is called "filature silk."

MARKETING SILK

The products of silk production are marketed in various forms. For example, in certain communities in Italy, there is a large business of selling certified silkworm eggs. These are usually sold at a certain price an ounce. Many silk growers sell the cocoons that they produce. The usual method of preparing them for market is to stifle the chrysalides by steam, by heating in ovens, or by freezing and then drying them thoroughly. When dry, they are sorted according to size, color, and quality, and are sold by weight. As a rule, small silkworm growers everywhere dispose of their product in this manner and at this stage. Finally, raw silk is marketed after it is reeled, some of it as reeled silk, and the parts that will not reel as silk waste. In the

Orient, silk is reeled into skeins of varying sizes, which are then packed into square blocks, called books, containing from five to ten pounds. The books are packed in bales, each weighing from 100 to 200 pounds or more. In 1912 the average price for a pound of reeled silk was between three and four dollars. From this it can be seen that a bale is a pretty valuable piece of goods.

Importations into this country.—Steamers coming from China and Japan to the western United States handle the silk as carefully as if it were gold. It is unloaded, usually at Seattle or San Francisco, and then taken east in baggage coaches directly to New York, the great American raw silk market. Often an entire train is made up of baggage coaches loaded with raw silk, and these "silk specials," as they are called, are given the right of way from coast to coast. Passenger trains, freight trains, and all must find the side tracks when the "silk special" passes through; and well they may, for the silk in each coach may average more than $125,000 in value, and the value of the entire train-load of silk may be $2,000,000.

Markets for waste silk.—Hartford, Connecticut, is the principal port of entry for the large quantities of silk waste and floss imported into this country. Boston comes second. Both are near the great New England silk mills (New London, Winsted, South Manchester, in Connecticut, and Pittsfield, Northampton, Holyoke, and Florence in Massachusetts) where large quantities of spun silk are produced. The center of reeled silk manufacture is in Paterson, New Jersey, and in the hard coal region of Pennsylvania. The state of New York also has a large number of establishments using reeled silk in some stage of manufacture.

CHAPTER XVII

SILK MANUFACTURING

United States first in silk manufacturing.—With the possible exception of China, for which no complete statistics are available, the United States is now the largest silk-manufacturing country in the world. This position has been taken from and maintained against France since 1905.

Rapid growth of industry.—The development of the silk-manufacturing industry of the United States during the last few years is one of the most interesting features of the country's progress. The phenomenal growth is shown by the fact that, since the Civil War, the increase in the gross value of such products is the difference between slightly less than $4,000,000 and nearly $197,000,000. The increase has thus been by leaps and bounds; trebling between 1860 and 1880; more than doubling during the next two decades; and increasing 83 per cent between 1899 and 1909. The United States now consumes more than one-third of the total amount of raw reeled silk produced in the world. More than 20,000,000 pounds of raw silk are imported each year.

Where the raw silk comes from.—Over half of it comes from Japan; a quarter comes from China; Italy supplies almost as much as China; and the remaining small amounts come from France, India, and other silk-producing countries.

Quality of the raw silks.—The finest raw silk to be found in any large quantity is that produced in Piedmont, Italy.

Chinese silk is ordinarily the poorest, not because of inferiority in silkworms, but rather because of the Chinese methods of handling it. Now and then some of the finest silk in the world comes from China, but too often great quantities of very poor fiber, wild silk, and weighted silk impair the Chinese product. Because no standards have been insisted upon by the government, the Chinese silk production and trade have degenerated. Japanese silk, however, is rapidly gaining in quality and reputation. The government has carefully promoted the industry, insisting on honesty and on scientific care in handling the fiber.

Silk consumption in the United States.—The Americans wear more silk than any other people. It is safe to say that the value of our per capita consumption of silk for men, women, and children is close to $2.50 per year. When times are good there is a tremendous increase in the sale of silks in this country, but in hard times, as in 1893, 1897, and 1907, silk sales fall off, the manufacturers' demands are checked, and the silk producers in Japan, China, and Italy are severely hit by our financial difficulties.

Fashion changes frequently, but there is no indication that silk will ever go out of style. Style ranges from one class of weaves to another, and from one kind of finish to another, but the "queenly fabric" continues to be the central thing in dress goods fashion.

Uses of the various kinds of silk.—The methods of manufacturing silk depend upon the uses to which the finished goods are to be put, but, generally speaking, reeled silk is used in the manufacture of fine cloth, ribbons, and fine sewing thread, while waste silk is used in making knit goods, hosiery, coarse cloth, braids and bindings, embroidery silk, crochet silk, and so on.

Kinds of silk yarn.—Various cloths require threads of different sizes. The warp and the weft usually vary considerably in all textiles. In making the finest silk webs,

threads known as "singles" are required. Singles are simply the silk threads as they are produced at the reeling. Sometimes singles are used as weft, and occasionally even as warp in the very thinnest fabrics.

Organzine.—In silk goods made from reeled silk the warp is called organzine and the weft is called tram. Organzine is prepared by twisting a single and then combining with other twisted singles, the number depending upon the size of thread wanted. The several threads are then twisted into one by twisting in the direction opposite to that given the singles. For example, if the singles are twisted by a turn toward the right, the combined singles are given a left-hand twist. The result is a hard-finished, smooth, strong thread that is comparatively small in diameter. The completed thread ready for the loom usually has from ten to fourteen turns to the inch.

Tram.—Tram is produced by combining singles in sufficient number—two, three, or more threads that have not already been twisted—and by giving these threads a rather loose twist. The thread or yarn resulting helps to give body to the cloth and shows the silk characteristics such as sheen and smoothness splendidly, but is not, of course, as strong a thread as the organzine. It usually has from three to six turns to the inch, depending upon the kind of fabric for which it is made.

Crepe yarn.—If the cloth to be produced is a crepe, the threads need a special treatment, especially the tram. The singles are put together as in making the regular tram, but instead of being twisted loosely, the thread is twisted very hard. Instead of two or three turns an inch as in tram, the yarn is twisted forty to eighty turns an inch. When woven into the fabric the elasticity of such threads causes them to "kick up" or crinkle. It is this that creates the crepe effect in the cloth. Crepe yarn is used in making crepe de chine, crepe charmeuse, crepe meteor, crepe faille,

crepe organzine in satin charmeuse, and the chiffons, as well as other fabrics. Crepe yarn is variously combined with regular yarns and in the different weaves, each variation producing a new effect in the appearance and feeling of the goods.

Special doublings.—In making gauze and certain fabrics with a watered appearance the yarn is prepared by twisting a coarse and a fine thread together. When this uneven combination is woven into cloth it gives a peculiar watered effect. This sort of yarn is called by the French *soie ondée.*

Other kinds of silk threads.—When we turn to the various kinds of silk threads and yarns which are not intended for use in cloth making, we meet with a very great variety. Among others there are machine twist, sewing silk, buttonhole twist, crochet silk, lace silk, filo silk, Persian floss, Roman floss, rope silk, etching silk, embroidery silk, dental floss, surgeon's silk, purse twist, knitting silk, and darning silk. In fact there is a different silk thread for practically every textile use. Silk is so useful that it may serve wherever any other textile can be used and in a number of other ways besides.

Sewing silk.—The manufacture of machine twist and sewing thread is a branch of especially great importance in this country. No other country makes any better; hence a considerable amount is every year exported to other countries. Nearly the entire process from raw reeled silk is conducted by machinery which is largely automatic. Sewing thread was the first silk product manufactured in this country and is the only one that has become important in America without the help of a protective tariff.

Machine twist.—In making machine twist or sewing silk, the reeled silk fibers are combined as in making tram, but they are twisted much harder than ordinary tram. Next, two of these twisted threads are combined and twisted in

the direction opposite to that used in twisting the strands. The product is sewing silk. In making machine twist three strands are used instead of two and the whole three hard twisted. Sewing silk is commonly called two-ply, and machine twist three-ply thread. After the twisting, the thread is passed through stretching machines that smooth and harden the fibers, giving the thread uniformity and evenness throughout. The thread is next washed, dyed, steam finished, softened, and then spooled, skeined, balled, or put up in whatever form the trade demands. There is about twice as much machine twist used as sewing thread. Practically all of it is taken by manufacturers of clothing, shoes, cloaks, gloves, and dresses. Manufacturers also use about half of the sewing silk produced, the other half finding its way into the homes of consumers through the channels of the dry goods trade. A fair assortment of sewing silk now includes not only the regular sizes but also upwards of two hundred colors or shades and tints.

Embroidery silk.—Embroidery silk is made by winding the raw silk, using a large number of single threads, giving them a slack twist, and then doubling and twisting in the reverse direction with a slack twist.

The other forms of threads and yarns are all prepared on the same principle, varying only in the number of single threads, the amount and direction of twist, the number of strands used, and so on.

Spun silk yarns.—Silk waste or floss is used in making spun silk yarns that are in turn used in the manufacture of lining silk, knit goods, hosiery, mufflers, cheap silk neckties, coarser numbers and qualities of sewing thread, pile fabrics, elastic webbing, dress goods of certain kinds, and in union goods such as mixtures with wool for fancy effects. Spun silk is also used in the manufacture of laces and embroideries. It can be used with very fine effects, but is less fine and strong than reeled silk.

Process of silk manufacture.—*Silk throwing.*—The first process of manufacture through which raw reeled silk must pass corresponds in some ways to the carding, combing, and spinning in cotton and wool. In silk manufacturing it is called throwing. When the silk arrives at the throwing mills it is usually in the form of skeins just as it came from the filatures in Japan, China, or Italy. Throwing naturally does not include the common processes of carding and combing, for the reason that the reeled silk is already in the form of thread. The only difficulty with it is that it is altogether too fine and delicate for use. Throwing is essentially a process of cleaning, doubling, and twisting the single fibers as they come from the filatures. To do this requires about a dozen processes, most of which used to require different machines, although modern machines often perform two or three processes at the same time.

Opening bales, assorting skeins, and scouring.—The first process includes opening the bales containing the skeins, assorting according to sizes, colors, and qualities of fiber, and laying up the skeins in piles of about five pounds each. Each of these piles is weighed carefully, placed in cotton canvas bags, and then taken to the soaking room. Here the bags containing the raw silk are placed in tanks of warm water in which considerable soap has been dissolved. The temperature is usually regulated at about 90° to 100°, and the silk is allowed to remain here for ten or twelve hours. This soaking softens the natural gum of the silk and makes it possible to unreel the silk from the skein with little difficulty or breakage.

Drying.—When the soaking has been concluded, the bags of silk are removed and the silk is placed in a drying machine which extracts the moisture by whirling the goods in a rapidly revolving, circular, sieve-like can. The centrifugal force of the rapid revolutions throws most of the moisture out of the skeins. Another drying method in common use,

but one taking longer time, is simply to hang the skeins on poles in a steam-heated chamber.

Softening.—When the skeins are fairly dried by either process, they are twisted, rolled, and rubbed either by hand or by machinery so as to soften any stiff or hard spots left after the soaking. When this is completed, the silk is ready to be wound on spools, or bobbins as they are called.

Silk throwing or winding.—Each skein is then carefully placed on a reel and made ready for unreeling. The tiny silk fiber is unrolled from the skein gently, yet at a high rate of speed. The winding apparatus here, as in nearly all other mechanisms used in textile industries, is fitted with apparatus that automatically stops the machine if anything goes wrong. Hence if the silk fiber coming off the reel should break, the machine would stop. This makes it possible for an operator in a silk winding room to take care of a great number of reels and bobbins. All that needs to be done is to replace empty reels with new skeins, to take away the full bobbins, and to attend to the difficulties causing breakage or stoppage of the machines.

Spinning or twisting.—The full bobbins are now taken to other machines that twist and combine the silk fibers into silk threads of various sizes. In making organzine, the single fiber is given a twist of several turns an inch before it is combined with others. The machine that combines the fibers is called the doubling frame, and the machine that twists the thread is called the twister. In some of the latest models of throwing machinery, the doubling and twisting is done on the same machine. These machines are so made that the number of turns to be given to the thread per inch can be exactly regulated. After the machine is once set and started, all that the operator needs to do is to replace empty bobbins with full ones from time to time and take away the twisted yarn bobbins when full. The doubling and twisting machinery is also equipped with automatic

stop motions. If a bobbin runs out, or if a thread breaks, that part of the machine stops at once until the operator has attended to the difficulty. One operator in a modern plant can watch a great number of spinning threads.

How the different yarns are made up.—It will be recalled that organzine is made up of several twisted singles, twisted hard in the direction opposite to the twist given the singles. Tram is composed of two or more singles twisted only a little. Sewing thread and machine twist is made by combining two or three tram twisted threads or strands into one hard twisted thread. Sewing thread is composed of two such strands, while machine twist is composed of three. An average size machine-twist thread contains about thirty singles; as each single for this purpose was originally made up of about twelve cocoon threads, the completed thread would contain about 360 cocoon threads.

Stretching.—After the twisting, the silk threads are run through another machine called a stretcher. In this machine the thread is first passed through a bath of soap and water and then drawn over rollers which stretch the thread at every point where it is larger in diameter than it should be. The process equalizes the diameter of the thread so that it becomes uniform throughout. Such inequalities result from uneven tension in the various threads in the doubling or twisting machines. After the stretching, the silk is reeled into skeins about fifty inches in length, containing, according to the size of the thread, from 500 to 2,500 yards.

Dyeing.—These skeins are then taken to the dye house if the silk is to be dyed. The first step in dyeing is the "boiling off" or scouring process. This removes the gum that is found in all natural silk. The skeins are immersed in boiling hot soapsuds and washed thoroughly. This process usually takes about four hours, and leaves the silk of a pearly white color and very glossy. Any discolorations

that remain are bleached out by means of sulphur fumes. Silk, as it comes from the scouring, is ready for any dye tint or shade. The number of colors that can be applied is very great. But the silk, while it gains in its adaptability to dyeing and also in its high gloss, loses about one-fourth of its weight and not a little strength. If the scouring and bleaching are not well and carefully done, the reduction in strength may be serious indeed.

Not all silks are scoured. Those to be used in making gauzes, crepes, flour bolting cloths, souples, and others are left in the natural gum. Other silks that are to be dyed with dark colors are only half scoured. After the scouring is completed, the silk threads or yarns are washed in cold water, reeled into skeins, dried, and then sent to the dye rooms. The process of dyeing is in general the same as for other textiles and will be considered in a later chapter. After dyeing, the skeins are again dried, run through another equalizing machine similar to the stretcher, and then rewound into the form in which they are wanted by consumers and the trade, such as spools, bobbins, skeins, etc. This completes the process of silk throwing. The silk is now ready for the weaver, the knitter, the lace maker, or the embroidery maker.

Use of machines in silk throwing.—Silk throwing is, as we have seen, highly mechanical. American machines are almost entirely automatic. The tending they require is very simple. No other country produces thrown silk any cheaper than this country, and American machines are fast displacing other types in other countries. The laborer in a silk-throwing mill (except for an occasional expert overseer or superintendent) needs little skill, and draws a small wage. Throwing mills are usually built in communities where cheap labor is abundantly available, especially that of women and children.

Localization of silk-throwing mills.—A typical section of

this kind is in the mining and heavy iron- and steel-manufacturing regions of Pennsylvania. Here large numbers of men are employed in the mines and in the steel mills, whereas the women of the workmen's families, especially the younger and unmarried members, have little opportunity to earn any money in a mining or manufacturing town of this class. The coming of the silk-throwing mills opens the doors of industrial opportunity to these classes. In such centers as Scranton, Wilkesbarre, Carbondale, Honesdale, Pottsville, Bethlehem, York, Altoona, Harrisburg, Lock Haven, Marietta, Phœnixville, Sunbury, and Williamsport, silk-throwing mills have thrived. Suitable labor has been abundant, fuel has been cheap, transportation from and to the great New York silk market has not been high, and the towns themselves have welcomed the mills with open arms, supplying them with suitable sites, low taxation, and in some cases even with bonuses sufficient to build the plants. From beginnings in silk throwing, other plants have sprung up in the same towns, producing finished articles such as ribbons, broad goods, linings, and other goods made with highly developed automatic machinery. A high protective tariff has for several years been a big help to the silk throwsters of this country. No wonder that silk manufactories have grown numerous during the last few years.

Preparation for weaving.—In the manufacture of silk fabrics, the process just described is the one followed where the warp and weft are dyed before weaving. Such goods are said to be "yarn dyed." From the throwing mills and dye works the silk is taken to the weaving mills to be made into cloth. The process of weaving is very similar to that previously described in the chapter on cotton manufacture.

Warping.—The bobbins holding the warp are sent to the warping room. About four hundred or five hundred bobbins are placed on a frame called a creel. From the creel the thread is unwound upon a warper reel in the proper

lengths which, for broad silks and dress goods, usually run from three hundred to six hundred yards per piece. If different colors are used, they are all properly arranged in order and number at this point.

From the warper reel the warp is wound onto the warp beams in sections, usually about thirty in number for yard-wide cloth. Cloth of this width will require from nine thousand to twenty-one thousand warp threads, depending in number upon the size of the warp used and the size of mesh desired. The process of winding the warp requires about one day's work of one skilled operator. Every layer of silk that goes onto the beam is separated from the rest by a sheet of stiff paper the width of the beam. This paper prevents the warp from becoming entangled on the beam.

Next the warp ends are passed through the loom harnesses, every thread being passed through its proper heddle eye. The ends are passed similarly through the reed, and then all is ready for the loom.

The process of threading the harness is usually shortened in a weaving mill by leaving in the harness and reed the last part of the warp of the piece previously woven, and then tying or twisting the ends of the old warp to the new. The new warp can then be pulled through into the harness at once. This process can be carried out much more quickly than when the new warp threads are to be passed through the heddle by hand. After the new warp has been passed through, the old ends are cut off, and the new ends knotted together in clusters to prevent their slipping back again.

Weaving.—The principle of the silk loom is the same as that of the cotton or wool loom, and need not be again described here.

Yarn-dyed and piece-dyed goods.—Silk goods are often woven before the dye process is begun. In this case, the raw silk wound upon bobbins is simply warped and beamed and then woven in just about the same way as the yarn-

Silk mill operative.

Silk weaving.

dyed goods. Such goods are frequently dyed or printed after the weaving. The name "piece-dyed goods" is given to those that receive coloring after the weaving has been completed. The next process for either piece-dyed or yarn-dyed goods is the finishing.

Where American mills excel.—In the weaving of plain goods, ribbons, and all goods that do not require a very high class of skilled labor, American mills now lead the world. Nearly all the ribbons used in this country, taffetas, dress goods, and staple lines are made here. The importations are largely high novelties, hand-made silk velvets, hand-made laces, and so on. For such goods as the highest class and most stylish ribbons, America still looks to St. Etienne, France. For the highest grade, soft finished, lustrous satins, and decorative silk brocades, people still look to Macclesfield, England. London still leads in the production of crepes. America also imports from Japan a considerable amount of extremely light weight and useful silk fabrics, such as habutai and kaiki silks.

Wherever automatic, high-speed machinery can be used and large-scale production carried on, there this country leads the world; but where cheap labor or very highly skilled labor is demanded in abundance, America must still give place to the older silk-manufacturing nations. The recent progress in textile invention has been so great and the promise for the future so bright that even in the high-grade novelties, this country may soon rival Europe. But if so, it will probably be through further improvements in mechanical means rather than through changes in labor conditions.

CHAPTER XVIII

THE MANUFACTURE OF SILK WASTE

Sources of silk waste.—In the production and manufacture of silk a large part of the cocoon fiber is unfit for reeling or working up into the finest grades of silk fabrics. As in the manufacture of cotton and wool, there is considerable waste of raw material in the many processes and machines that are required. This so-called waste is by no means wasted. It is all carefully collected and used in the manufacture of goods differing only in grade from the highest priced fabrics.

Most of the wastes originate in the reeling process. First there is the outer part of the cocoons, the floss, which must be brushed off before reeling can begin. Then there is the inner part of the cocoon next to the chrysalis, which can never be entirely reeled off. Then, too, there are always a large number of imperfect cocoons that yield little or no fiber suitable for reeling. All cocoons left for binding purposes and pierced at the end cannot be reeled and must be converted like other silk waste. Nor must we forget the waste fibers from the reel, short and tangled, and all needing to be worked over. Clippings, loose threads, and so on from dressmakers' establishments, from the silk goods manufactories, and from ragpickers' carts are all reclaimed and made into silk shoddy by running through shedding machines that tear up the material into fine floss. The process closely resembles that used in making wool shoddy.

Variations in methods of use.—Naturally the method of utilizing silk wastes varies considerably according to the character of the waste. Raw waste from the cocoons needs a treatment differing from that given to silk shoddy. Short-fibered waste is treated differently from long-fibered waste, while colored waste goes through processes not at all used with white or uncolored wastes. Obviously, the first step in the manufacture of silk wastes is classification of the material into as many varieties as may seem practicable. Some of this sorting and classifying is done by the producers of raw silk, some by the silk rag dealers who gather the wastes from makers-up, but most of the sorting is done in the silk manufactory.

Degumming raw silk waste.—If the silk waste is raw, the first step is to remove the gum or sericin. There are two methods commonly employed, one usually practiced in France, Italy, and Switzerland, and the other in England and this country. The first is called the schappe method, and the latter is called the boiling off method. In the schappe method the raw silk waste is turned into large vats in rooms that are kept damp and warm. Here the silk begins to ferment, and this fermentation loosens the gum so that it may be washed away easily. The odor given off by the fermenting silk is so intensely offensive, however, that all such silk-washing plants must be located far from any human habitation. Workers in the plants grow accustomed to the stench and mind it comparatively little. The advantages claimed for this method are that the silk fiber left after washing is very glossy and that its strength has not been impaired in the least, if the fermentation is stopped at the right time.

Boiling off method.—The English method consists in dumping the silk waste into cotton cloth bags and immersing them for some time in boiling soapsuds. This loosens the sericin or gum quickly and without any offensive odor.

This boiling process is about the same in principle as that employed in removing the gum from the reeled silk.

Conditioning.—After the silk waste has been degummed it is ready for conditioning. It is washed, and then dried to the point where it will work best in the subsequent mechanical processes. Especially if it is to be sold before going through further processes, the conditioning as to the right amount of moisture is looked after very carefully before the goods are finally weighed out. Some moisture is necessary in order to have the silk work smoothly without becoming charged with static electricity.

Beating and opening.—The next process in its manufacture is running it through a machine called a beater. The fibers are pounded and beaten thoroughly to loosen them from each other and to dislodge any foreign matter not dissolved in the boiling off or degumming process. From the beater the fibers are passed into another machine called an opener. This loosens all the lumps and makes the whole mass more fluffy. When the waste is made up of very long fibers, they are sometimes cut up into smaller pieces which will work more easily and smoothly.

Carding and combing.—The next machine, known in England as a filling engine, cards and lays out the loose fibers in thin laps or strips similar to the card laps in the cotton and woolen industries. In all the better grades of silk waste, the next step is combing. This process is very similar to wool combing in the worsted industry, but in spun-silk manufacturing it is called silk dressing. The lap is run into the combing machine and the combed fiber may be re-combed again and again, often as many as five or six times. Each combing is known as a draft. A considerable amount of silk noil is separated from the fiber. The better noils are mixed with loose silk waste to be worked over again. Medium grades of silk noils are used in making noil yarns and as such are frequently used in making

silk and wool mixtures. The shortest noils are mixed with the coarsest and poorest waste silks. These are not combed at all but simply carded and spun into yarn as in making yarn of short-fibered cottons.

Drawing and spinning.—After the waste silk is properly combed the silk tops are put through gill boxes and drawing frames and reduced first to slubbing and then to roving in the same way as in combed wool production. The rovings are next spun on mule frames and usually doubled. This completes the spinning process. The yarns, after being finished by singeing or gassing so that all fuzziness may be destroyed, are ready for weaving.

Qualities of spun silk.—Spun silk is not quite so lustrous as thrown silk although it still retains much of the appearance and quality of that product. Nor is it so strong as thrown silk. But in both strength and luster much depends upon the quality of the waste from which it is made up. Length and evenness of fiber very largely determine the appearance. The care used in dressing and spinning also adds to the strength and luster.

Sometimes the silk waste is spun in the gum and the degumming process is not applied until the manufacturing processes are completed.

Uses of spun silk yarns.—The best grades of spun silk yarn are used as filling or weft in several varieties of silk fabrics, both plain and twill, and in pile goods such as velvets. Spun silk yarn of high grade is also used as warp in goods that have a cotton or wool filling. A considerable amount is used in the production of embroidery and knitting silks.

Lower grades of spun silk yarns are used in making ribbons and silk cords, while the cheapest grades are used in making knit goods and the poorest and coarsest silk or silk-mixed fabrics. The poorest grades of spun silk, those which are carded only and not combed, are used as filling

in cheaper grades of silk dress goods, in the silk upholstery fabrics, in polishing cloths, and in coarse grades of knit goods. The lowest grades of silk waste are used as steam pipe packing and as insulation material around electrical wires and in electrical instruments. Silk is a poor conductor of heat and also of electricity, especially when dry; hence these uses for other than clothing purposes.

CHAPTER XIX

IMITATIONS OF SILK

Reasons for imitating silk.—Silk, the most beautiful as well as the strongest of all textile fibers, is naturally in strong demand the world over. Nothing but its high cost of production prevents its more general use. One does not wonder that there is much interest in finding substitutes for this great fiber, or cheaper materials which combine as many of the qualities of true silk as possible; such, for example, as its high luster, its steel-like strength, its attractive smoothness and softness, its elasticity, and its quality of taking the most delicate tints and shades in the dyeing process. Many experiments have been tried, much money has been expended, and much human energy exhausted in the desire to find such suitable substitutes. Many vegetable fibers such as cotton, ramie, linen, wood fiber, kapok, and others have been used in one way or another with some degree of success. Various finishing processes have been invented to give to cheaper fibers the appearance of silk, such as gassing or singeing, glossing, beating, and polishing.

MERCERIZED COTTON

None of the imitations of silk has been more widely adopted than mercerized cotton. Mercerization is a process applied to cotton yarns or fabrics which gives to the cotton fiber a silk-like luster, a somewhat greater strength

than that of ordinary cotton, and a greater affinity for dyes. Mercerized cotton is at the present time a direct competitor of silk in a great number of ways, both as an imitation and as a substitute. Its qualities are so excellent, however, that were it not for its value as a silk substitute it would still rank above ordinary cotton in its own right. Mercerized cotton has proved itself a most desirable addition to the textiles.

John Mercer.—The process of mercerizing cotton was discovered about 1844, by an Englishman named John Mercer, but he thought so little of his discovery that he took no patent on the process until 1850. At the time of his invention, he was a chemist in a large calico printing plant. His name is well known in textile chemistry. Besides mercerization, he invented several styles of calico printing and prepared for the first time a sulphonated oil (known as Turkey red oil) ever since used in producing certain fast dyes. He was the inventor of the blue-print photographic process, and also of several medical or pharmaceutical preparations.

Story of mercerized cotton.—Samples of mercerized cloth were exhibited at a world's fair in London in 1857 and attracted considerable attention; but the cost of the chemicals used in mercerizing was then so high that the process seemed hardly feasible. Mercer, who died in 1866, was therefore in no way benefited by this valuable invention. Not until the later eighties did mercerization become practical, and then for two reasons. First, certain improvements were discovered in the methods of mercerizing; and, second, the cost of the needful chemicals had considerably lessened since Mercer's time. By 1900 mercerized cotton was in extensive demand and the annual production and consumption have climbed every year since then. Its use is now widespread in a great number of fabrics, as the sole textile in some cases, as the warp in others, as filling

in still others. In almost every sort of fabric in which silk is used, mercerized cotton is also employed. Its cheapness permits its use in a number of things for which silk would be impracticable because of prohibitive cost.

The mercerizing process.—The process of mercerization is simple in principle. It consists simply in soaking the cotton or other vegetable fiber in strong caustic soda or caustic potash solutions for a few moments and then washing in pure water to remove the caustic. The resulting change in the fiber as to appearance and quality is called mercerization. What actually takes place may be briefly explained. It will be recalled that cotton fiber is composed of almost pure cellulose. Caustics, when strong, attack these cellulose fibers, causing them to swell in diameter and contract in length. In natural condition the single cotton fiber is a flat, ribbon-like filament, but when immersed in caustic solutions it swells out and takes on a round and hair-like appearance, plump instead of flat. The difference between a mercerized fiber and an untreated fiber can be seen easily under a microscope. This change in form of the fiber is accompanied by a change in the substance. The cellulose is changed into another kind of chemical substance called cellulose hydrate or hydro-cellulose. The principal difference between this substance and the old cellulose is that it has a much greater affinity for dye substances. Cellulose cannot be dyed very easily except with certain very powerful dyes. Hydro-cellulose, on the other hand, absorbs almost any kind of dye readily and quickly. In fact, in dyeing mercerized cotton, it is customary to put in chemicals to check the process in order that the dyes may not enter so rapidly as to render the shading uneven.

Qualities of mercerized cotton.—Loose cotton fibers placed in the caustic solution contract considerably, thus increasing the strength of the fiber. Hence, mercerized cottons, unless stretched too much, are generally considerably

stronger than untreated cottons. Not only does the contraction of the fiber strengthen it, but also the thickening of the diameter due to the expansion already described stiffens the structure of the fiber. This much Mercer discovered in 1844 and described in his application for a patent in 1850. But the silk-like luster that we now look for in mercerized cottons had not yet been developed. About 1890 some textile makers in Germany were experimenting with the mercerizing process on yarns and woven cloth. It was found, as has already been suggested, that the process shortened the fibers, and consequently caused a noticeable shrinking in the yarn and cloth. This, the experimenters felt, was a disadvantage, and so they concluded that they would attempt to prevent this shrinkage by stretching the cloth and keeping it stretched full length while it was being mercerized. They were successful in keeping the fabric from shrinking, but what was their surprise, on taking the cloth out of the caustic and washing it, to find that it had a beautiful, silk-like luster! The commercial possibilities of this discovery were not overlooked. A description of the process was quickly rushed to the patent offices of all countries, and mercerized cotton, glossy, smooth, and strong, became a big factor in commerce within a few years. Under the low tariff of the Democratic administration from 1893 to 1897, European mercerized cottons were introduced into America, and American manufacturers presently began to produce the same sorts of goods for home consumption. Since 1903 the use of mercerized cotton has increased by leaps and bounds in about the same proportions as silk has increased in American use. When the fashions dictate a great vogue in silks, then mercerized cotton likewise leaps forward. When silks recede slightly, mercerized cotton feels the change also.

Modern methods of mercerizing.—The modern methods of producing mercerized cotton closely follow the principle

discovered by Mercer, together with the improvements discovered in 1890. Yarn or cloth that is to be mercerized is first given a soap and water scouring, soaked in clean water, and then run through rollers that extract most of the moisture. Next the material is run into the caustic solution bath, at a temperature of about 65° Fahrenheit, where it remains from ten to fifteen minutes; longer would prove disastrous to the fabric. Sometimes the material is run through this bath in stretched condition; more frequently it is simply soaked in the caustic, removed, and then stretched before being rinsed. This seems to give the best results. After the cloth or yarn is stretched to its original length, it is washed in water to which acid has been added to counteract the action of the caustic in the material. Sulphuric acid is the cheapest and most commonly used. Its use requires care, however, for slight overuse would harm the mercerized cotton as much as overexposure to the caustic. Acetic acid is not infrequently used since it is not at all dangerous to the cotton fiber and has the added advantage of giving to the mercerized cotton the feeling and the tendency to rustle, the "scroop," as it is called, that is found in true silk. Acetic acid is more expensive than sulphuric acid. Tartaric acid produces effects similar to acetic acid.

Bleaching generally follows the mercerizing process, because, if done previously, it slows down the mercerization, whereas mercerization is not affected by subsequent bleaching. The fabric is now ready for the finishing processes such as dyeing, singeing, polishing, and calendering. An excellent luster is obtained by singeing or gassing the yarns before they are mercerized. Too many of the little fine linty hairs found on the surface of cotton yarn dull the luster; hence, gassing is necessary either before or after the mercerizing process.

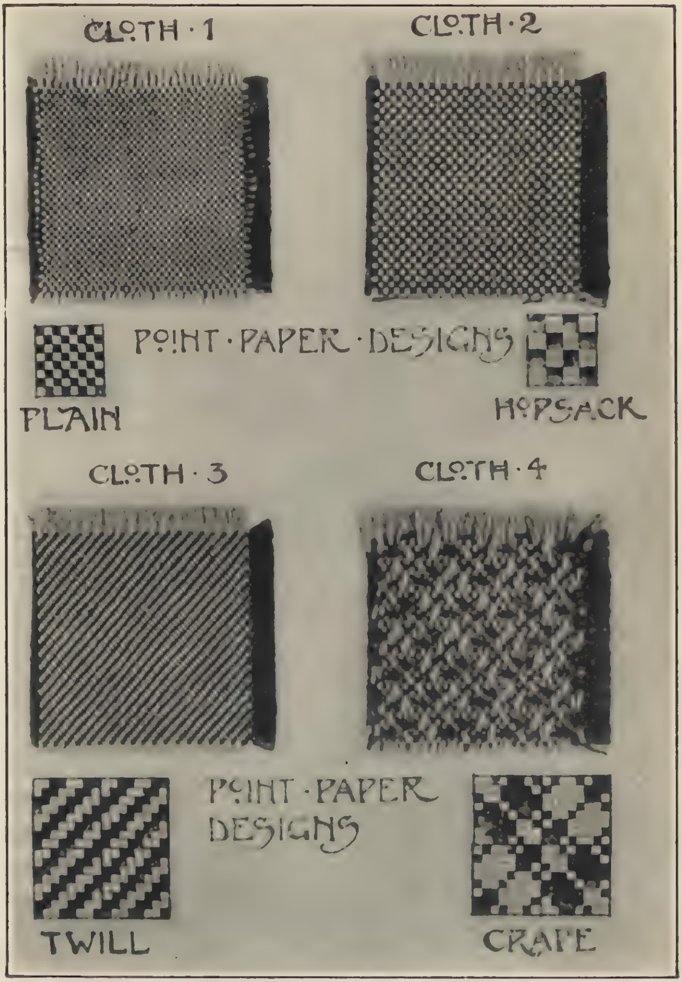
Any strong caustic causes cellulose to mercerize. Caustic soda, the cheapest of all, is most generally used. Caustic

potash, while somewhat more expensive, gives a little better luster. Sodium peroxide gives a still better luster, although it entails other dangers, as for example, fire. Zinc chloride and several other substances are suitable but caustic soda is the most commonly used. To this a little carbon disulphide is sometimes added, which helps to give a better luster. In some cases alcohol is added to hasten the penetration or impregnation of the cotton fiber by the caustic solutions.

Several attempts have been made to bleach and mercerize in one operation and thereby to lessen the time and expense involved in the production of mercerized fabrics. No success has yet been attained in these experiments.

Mercerizing fibers other than cotton.—From what has just been said about the process of mercerization it is easily inferred that not only cotton but any fiber containing cellulose may be mercerized. Linen, ramie, jute, and wood fibers, and even paper have been successfully mercerized. But for textile purposes, since cotton is one of the cheapest and most adaptable clothing fibers, it is ordinarily used.

What cottons are best suited to mercerization.—Any length of cotton fiber can be mercerized; where a high luster or gloss is desired, it is advantageous to begin with long fibers having as much natural luster as possible. For this reason sea-island and Egyptian cottons are best suited for the finer mercerized goods. The fibers must be stretched either in or after the caustic bath. The long fibers of sea-island cotton are more easily stretched in the yarn or in the cloth than are the upland cotton fibers. Short fibers must be spun into hard-twisted yarns in order to stand the pull; this hard twist in the yarn of such cottons makes it somewhat difficult for the caustic solution to penetrate evenly. The long fibers of sea-island or Egyptian cotton can easily stand the stretching process even in a loose-twisted yarn.



STANDARD WEAVES.

Cottons are combed rather than carded.—Yarns to be mercerized are combed rather than carded, and it is not unusual to double-comb the fibers in order to make sure that all lie as nearly parallel as possible. After the combing process, any needed twist is given, after which the yarn may be gassed, as already suggested, before treatment in the caustic bath.

Stretching.—Some manufacturers have experimented to see just how much stretching is necessary to get the highest luster. There is considerable difference of opinion upon this point. Some claim that the highest luster is obtained by stretching almost to the breaking point; others claim that no additional luster can be gained by stretching cloth or yarn beyond its original length. It seems certain, however, that high degrees of luster found in mercerized cotton are almost always accompanied by a weakening in the strength of fiber. Mercerized yarn that has not been stretched is much stronger than the same size of ordinary cotton yarn. Even when the mercerized yarn has been stretched to its original length, the length before treatment with caustic, it is still somewhat stronger than ordinary yarn. Stretching it beyond this point, however, increases the luster at the expense of fiber strength.

Uses of mercerized cotton.—Mercerized cotton answers many purposes. It is found in such materials as sateens, silkoline, tubsilk, cotton taffeta, linings, dress goods, skirtings, and in embroidery and crochet yarns in its own name. But it is also used in a great number of so-called silk-mixed fabrics, such as silk-mixed mohair, silk-mixed alpaca, silk-mixed woolen and worsted figured goods, silk-mixed worsteds for men's wear, silk-mixed cottons, and so on. It is frequently used in figured cotton damask tablecloths and napkins. Mercerized cottons likewise figure largely in upholstery goods, draperies, curtains, and coverings.

Producing crepe effects by mercerization.—The princi-

ple of mercerization is sometimes employed to secure crepe effects in union goods, the mercerization attacking only one class of fibers or yarns, as for example the cotton threads introduced at regular intervals in a woolen structure. Such fabrics are called crepons. Between 1895 and 1900 these fabrics had a great vogue in this country. Most of the goods were imported from Germany. How this peculiar effect was obtained was for a considerable time a puzzle to Americans until they finally discovered that the drawn up effect, the creping, was due to the shrinking by mercerizing of cotton threads inserted at the time of weaving into the woolen fabric, the wool remaining unaffected by the process.

Special applications of mercerization.—Not always is the whole fabric mercerized in piece-goods mercerization. Sometimes the cloth to be mercerized is covered with a paste, leaving the cloth exposed only in certain places in the form of figures. In this condition the cloth is immersed in the caustic bath with the result that only the open figures are mercerized, the protected portions remaining plain cotton. The possible variations in finish may be made even more numerous by the dyeing process. Colors may be applied which dye the ordinary cotton faintly while giving the mercerized figures a very full, deep color. Another common method of part mercerization is by mercerizing the cotton cloth in stripes. This gives the seersucker effect. Several other similar types of manipulation are possible, although of interest mainly to the textile manufacturer.

SILK SURFACING

Another method of so treating cotton yarn as to make it look like silk has had considerable success, though not nearly so important as mercerizing. This method consists

in soaking smooth cotton yarns in a solution of pure silk made by dissolving silk remnants and silk waste in some acid. A considerable amount of silk waste not used in spinning is disposed of in this way. The cotton yarn is first soaked in tannic acid or in some metallic acid solution, and then transferred to the silk solution bath. The preliminary acid treatment causes the cotton more readily to take up the silk solution. After soaking in the silk liquid bath, the cotton yarns are dried, run between heavy rollers, gassed, and polished. Yarn so treated has a fine silk-like appearance. The cotton is indeed covered with a very thin film of true silk. Unfortunately this finish has very little durability, and its use is limited to goods which call for little hard wear or washing.

THE ARTIFICIAL PRODUCTION OF SILK

There is still another method of imitating silk which from the standpoint of textile chemistry is really more fundamental than either of the methods just described. For a long time the chemical composition of silk has been accurately known. Its method of production by the silkworm is pretty well understood. As will be recalled, this process consists simply of giving out thin filaments from the thick, sticky mass of silk gum found in the two sacks in the silkworm's body, the filament hardening into a strong fiber as soon as it comes into contact with the air. This simple process has suggested to many persons the possibility of artificially producing a gum of the same or similar chemical composition, a gum that would harden when pulled out into a fine hair-like thread. A great French scientist named Réaumur suggested as far back as 1734 the possibility of the discovery and production of artificial silk. His own experiments were confined to the use of different

kinds of varnish forced through minute holes in the bottom of sheet-iron or tin cans. The fibers hardened like true silk but no satisfactory use was ever made of them in a practical way.

Andemars.—Not until 1855 was the subject revived again. In that year a Swedish chemist, Andemars, took out patents in the various European countries on a process of making artificial silk of cellulose pulp. It will be recalled from our study of cotton and linen that both of these fibers are nearly pure cellulose. Andemars made his cellulose from the inner bark of mulberry trees dissolved in alcohol and ether. From this sticky substance he drew out threads which hardened in the air after the fashion of genuine silk fiber. Cellulose differs from the silk substance mainly in the fact that it contains no nitrogen, whereas silk is about one-fifth nitrogen.

Swan.—In 1883 an Englishman, J. W. Swan, discovered a method of making a pulp from cotton fibers by dissolving them in alcohol and ether. He passed this pulp through very small openings and then hardened it by passing it through water. The result was a number of fine silk-like threads. Swan made only a few experiments with his invention in the textile field. The product which he made was very inflammable; in fact, its composition was about the same as that of gun cotton or nitro-cellulose, and likely to explode with serious consequences. Few of us ardently desire to wear clothing of that character or to have our neighbors so clad. No insurance company would insure a building in which this material was made or stored. The early prejudice aroused against artificial silk because of its inflammability exists even to this day in certain European countries. In these countries fire insurance is not sold to any producer of cellulose silk.

Chardonnet.—At about the time when Andemars took out his patent and continuing for several years later, a

Frenchman named Chardonnet began to experiment in the making of artificial silk. He also used cotton, especially cheap cotton wastes, and made his sticky pulp paste by dissolving the cotton in alcohol and ether. Chardonnet's first factory was started at Besançon, France. Although he was wealthy before beginning his experiments, in the course of a few years of experience with artificial silk making he went into bankruptcy. This did not discourage him. With the help of other men's capital he tried one method after another, until he achieved success in the making of artificial silk. Chardonnet ranks in the textile field with Eli Whitney, the inventor of the cotton gin, and Elias Howe, the inventor of the sewing machine. Neither of these was able to enjoy during his life any material fruits of his labor. Chardonnet, however, lived to see his invention of cellulose silk adopted as practical by the commercial world. Chardonnet silk gained the esteem of the public in 1889, when several artificial silk products were displayed at the Paris Exhibition. Commercial demand can really be traced from that date.

Chardonnet's process, as he finally perfected it, did not end all experimenting in making artificial silk. In fact, Chardonnet silk, while it is yet made in greater quantities than any other, seems destined to be superseded by better artificial silks, such as the cuprammonium and viscose varieties. But Chardonnet's process paved the way to practical use of this highly important textile. He solved the problem of making the artificial silk non-explosive; he succeeded in making it even less inflammable than ordinary cotton.

Other varieties of artificial silk.—Three other varieties of artificial silk have been tried. One of these, gelatin silk, the one which in chemical composition most nearly resembles true silk, has proved the least satisfactory. None whatever is made now for practical uses. Gelatin silk is

sometimes called vanduara silk. The other two are cuprammonium and viscose silks.

Cuprammonium silk.—In making cuprammonium silk, cotton cellulose is dissolved into a paste by means of cuprammonium, or ammoniacal solution of cupric oxide, instead of alcohol and ether. The fibers are drawn in jets from the cylinder in which the paste is compressed and are hardened in acetic acid. A considerable amount of this artificial silk is made in Germany. It is known in the German language as glanzstoff.

Viscose silk.—Viscose silk is made from wood pulp, generally that of spruce wood. This substance also is mostly cellulose but acts somewhat differently from cotton cellulose. Wood cellulose is dissolved in strong alkali and carbon bisulphide. The paste formed is called viscose. This is made into fibers by being forced through tiny pipes or jets and hardened in a solution of ammonium chloride. Viscose silk is likely to be the most popular of the artificial silks. Its qualities seem to be somewhat better than those of either the Chardonnet or the cuprammonium silks, while the cost of making is somewhat less. Chardonnet and cuprammonium silks are still made in large quantities in France, Switzerland, England, Belgium, and Germany, but in the one large artificial silk factory in the United States, located near Philadelphia, viscose silk is the product manufactured.

Experiments going on.—Experimentation is still going on. Great discoveries are still likely to be made in the production of this textile material. There are now nearly a score of processes besides the four mentioned above, but the three noted as successful are the ones which are used in producing fully nine-tenths of the commercial artificial silk. It is noteworthy that the American plant near Philadelphia expended over a million dollars in tests and experiments before a pound of the yarn was sold. Recently there

has appeared the advertising of new artificial silk which does not have some of the objectionable features of ordinary artificial silk, such, for example, as the tendency to weaken and go to pieces in water.

Qualities of artificial silk.—The Chardonnet process silks together with other products made by using similar chemicals (that is, pulp, ether, and alcohol) are sometimes called pyroxylin silks. Occasionally they are called collodion silks; viscose silk is sometimes called wood silk. All of the artificial silks are very bright in luster, even more so than true silk. They are usually stiffer, and may or may not have the feel of true silk. Most varieties are somewhat harsher than true silk, and none have its elasticity. The size of the filaments varies, but artificial silk can be made as fine as natural silk. In making ordinary artificial silk the diameter of the filament is usually about 4/1000 of an inch. It takes about 33,000 yards of such filaments to make a pound. A single yarn is usually made up of from fifteen to twenty filaments. The yarn made of artificial silk is not so strong as true silk yarn of the same size, but while dry it is considerably stronger than cotton. Until recently, at least, no method has been discovered to keep the filaments from weakening in moisture. When wet, the yarns are usually not more than about a sixth as strong as when dry. This has been one of the main objections to artificial silk, since it is necessary to use it in only such goods as do not become wet or need washing.

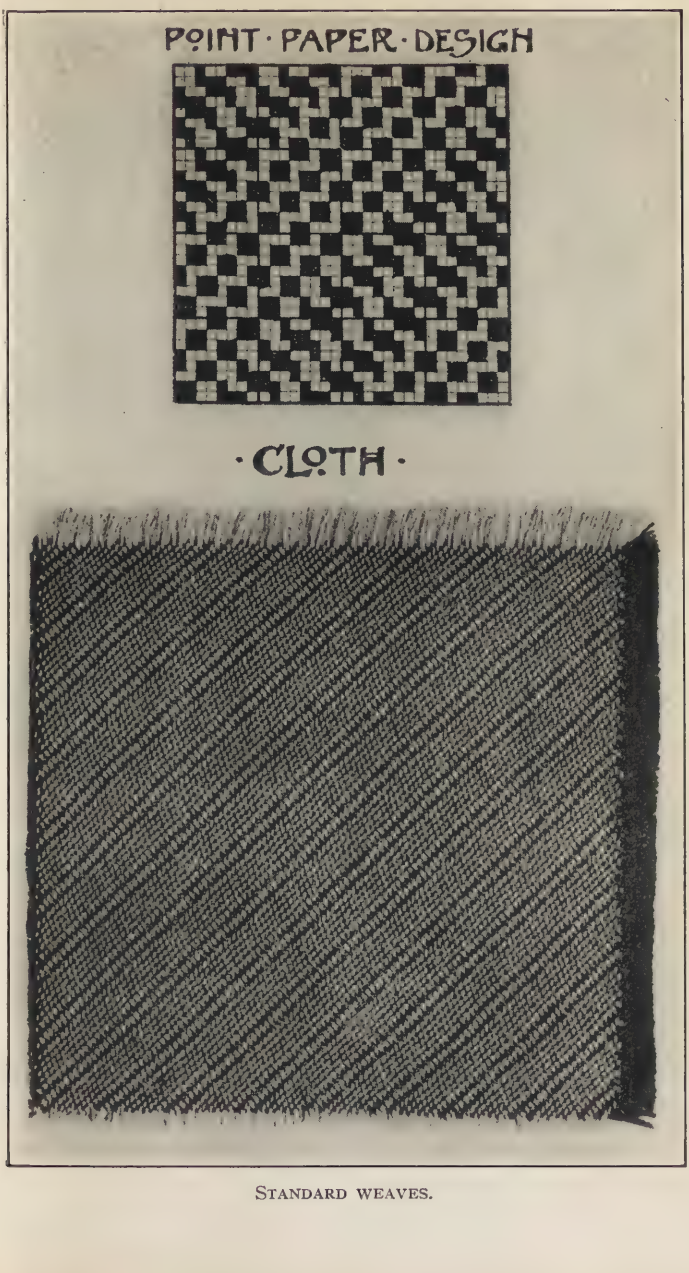
Artificial silk seems incapable of withstanding high temperatures. At a temperature of about 300° Fahrenheit it chars and is destroyed. Cotton, wool, and true silk all stand considerably higher temperatures than this before being materially injured. Hence, artificial silk must be handled very carefully when calendered or ironed. Using flatirons at the temperatures appropriate for cotton or even true silk would ruin artificial silk.

Amounts of artificial silk used and value.—It is estimated that the amount of artificial silk used in this country at present is nearly one-fifth as great as the quantity of true silk. This is probably too large an estimate, but the amount used is certainly increasing every season. The cost of the yarns ranges from $1.75 to $2.50 a pound, whereas real silks cost more than twice as much.

Uses of artificial silk.—Artificial silk is used mainly in the production of braids, passementerie, trimmings for hats and dresses, knit neckties, curtains, tapestries, ribbons, and as the warp in certain kinds of dress goods. A recent estimate made in the *Scientific American* states that fully ninety per cent of all silk braids and passementerie is now made from artificial silk.

Artificial silk cloth.—Artificial silk cloth is not necessarily made in the usual way by making artificial silk threads into yarn and then weaving cloth from the yarn. A much quicker process is sometimes employed. The pulp or paste may be poured over a large flat surface rolled out thin and then marked with rollers engraved in such a way as to give the material the appearance of having been woven. In this way much millinery silk is made, as for instance, tulle or maline. The appearance is good, the cost is low, and the service is excellent so long as the fabric remains dry. Almost any sort of weave may be imitated by this process.

Mixing other fibers with silk.—Silk itself is often mixed with baser and cheaper fibers in such a way as to show on the outside any silk that exists in the fabric. Cotton-backed satins, cotton-mixed pile fabrics, silk warp cotton and wool goods, and so on are lines in which silk is so manipulated. Such treatment is entirely legitimate so long as buyers know what they are getting. Some very desirable and inexpensive fabrics are made up of silk mixed with other textiles, the beauty of the silk going far towards reclaiming and beautifying the cheaper and coarser fibers.



Standard weaves.

SILK WEIGHTING

But there is another method of using silk that is less fair, since it adds no utility to the fabric. This is silk adulteration. The most common method is by means of weighting. By means of weighting the manufacturer can take a pound of raw silk and turn out therefrom as many as three or four pounds of silk cloth or even more. The product is a cheat and even the pound of true silk used is spoiled by the addition of the weighting.

Object of weighting.—As a rule only reeled silks are weighted. Spun silk is so much cheaper that it does not pay to introduce the weighting materials and expend the time and labor necessary to increase the weight. Reeled silk is high in value and much in demand; hence the constant temptation to make the silk go farther than it really should by means of loose, sleazy weaving, the necessary weight being added by means of adulterations. Certain exceptions to this statement should be noted, however. Knit silk mufflers, scarfs, and hoods made of waste silk are legitimately weighted. The additional weight gives a better feeling to this class of goods.

Means of weighting silk have been known for many centuries, but as a commercial practice weighting does not date back much more than thirty or thirty-five years. Silk dresses made before that time cost more than they do now, but they wore proportionately better. Silk is the strongest and most durable of all textiles when properly prepared, but when weighted it loses much of its strength.

Weighting of raw silk.—The Chinese have been adepts in weighting silk. For years it was almost impossible to get a pound of pure silk from this country. Every pound of silk yarn had been increased to two or three by means of weighting with acetate of lead. Suspicion grew to such

an extent that it severely hurt the Chinese silk trade. The government of China has taken some steps to stop the practice. Foreign silk buyers have established themselves in several of the silk districts in China; they buy nothing but cocoons which they have reeled in their own filatures, to make sure that they may have nothing but pure raw silk to send abroad. Sometimes, also, weighting is applied after the raw silk has been thrown and while it is being made ready for dyeing.

Weighting substances used.—The substances used in weighting silks include tannin in any one of several forms, salts of metals such as iron, tin, chromium, sodium, magnesium, and barium, and such substances as sugar, glucose, gelatin, glycerin, and paraffin. This list by no means includes all that may be used. However, tannin, iron, tin, and sugar are the most common.

Explanation of weighting.—Weighting depends upon the fact that silk has great absorptive power. For example, a pound of pure raw silk will absorb nearly half a pound of tannin in any of its several forms before giving any visible indication of being changed in character. Furthermore tannin has a marked affinity for certain metals, such as iron and tin, in the form of chemical salts. A pound of silk loaded with tannin and soaked in solutions of iron salt will take up iron to the extent of another half-pound without any visible effect in the silk. By adding more chemicals of various kinds, the total weight of the pound of raw silk may be brought up to three or four pounds, and in some experiments has been brought up to nine pounds, before the apparent silk qualities of the yarn or cloth were lost. Silks to be given a dark or black dye will stand more weighting than light-colored silks, for the latter are likely to be discolored by too much weighting. Iron salts are most suitable and cheapest for the dark-colored silks; tin salts are used for the light-colored silks.

Methods of weighting silk.—The usual method of application of weighting is somewhat as follows. In the boiling-off process, by which the natural gum of the silk is removed, the silk loses approximately one-fifth of its weight. It has always been felt legitimate to add weighting to this extent. In fact, a silk that contains no more than this amount of weighting is called a pure dye silk. The silk is immersed in a solution of catechu, cutch, or some other substance rich in tannin. The lost fifth is quickly replaced by the tannin. But the ease with which iron or tin may be added and the demands for silk cloth of considerable weight, cause silk manufacturers to transfer the silk from the tannin vats to the iron or tin baths. After this, the cloth is taken out, washed in pure water, and tests are made to see how much weighting has been added. If it is felt that more will prove profitable, the silk goes back through the weighting baths again, sometimes more than once. After the weighting and washing are completed, the silks are ready for the dyeing.

Effects of weighting.—The results of weighting may be most disastrous to the life of the silk. In the first place, the fabric begins to lose its strength as soon as weighting is applied. The more the weighting, the less the strength. Wearing the silk soon causes it to disintegrate and laying it away or storing it causes it to crack or crumble. Heavily weighted silk must be worked up into garments or whatever else it is intended for very soon after it is made; otherwise in a few months it becomes useless. Spots develop in the dye after a time, perhaps because of unevenness in weighting or from other causes. Salt water, perspiration, and tears cause spots to be formed, spots which sometimes disintegrate as if the places touched had been eaten out by strong acids. Sunlight attacks weighted silk, and, were it not for the addition of certain counteracting chemicals, would soon cause the silk to fall to pieces. No matter what one does

with weighted silk, it is certain to lose its usefulness in a comparatively short time. If one uses it, it wears out; if one lays it away, it cracks, crumbles, or rots to pieces. Neither storage in light nor in darkness can save it.

CHAPTER XX

CONSTRUCTION, COLOR, AND FINISH OF CLOTH

CLOTH DESIGNING

The appearance of the cloth is a vital factor in the success of the textile business. The eye of the consumer must find the fabric attractive. Costly experiments are made to find out what people want. The designing of fabrics is an art that ranks with the highest, since it requires both a high grade of technical skill and that broad knowledge of markets which comes from genuine knowledge of people. Designers must be close students of style tendencies, of current fashions, and of popular taste. The one who works out designs for new fabrics must consider such matters as seasonal or climatic demands, appropriateness to use, appropriateness with reference to other materials with which the fabrics are likely to be used, the artistic standards of the people to whom the goods are to be offered, harmony and beauty in the designs, etc.

Sources of designs.—Successful designers of fabrics are not numerous. The majority of designs fail to meet popular approval. Naturally, then, successful fabric designers can command high salaries. Many of the designs made in this country imitate those already produced in Europe, France, Germany, or England. The American designer in such cases merely copies, or else makes some simple change which seems to him likely to appeal to the American.

General methods of varying the design.—There are in general three methods used to vary the appearance of cloth; namely, variations in weave, in color, and in finishing methods. These, together with some of their applications, may best be given at first in an outline.

I. Variations in weaving.

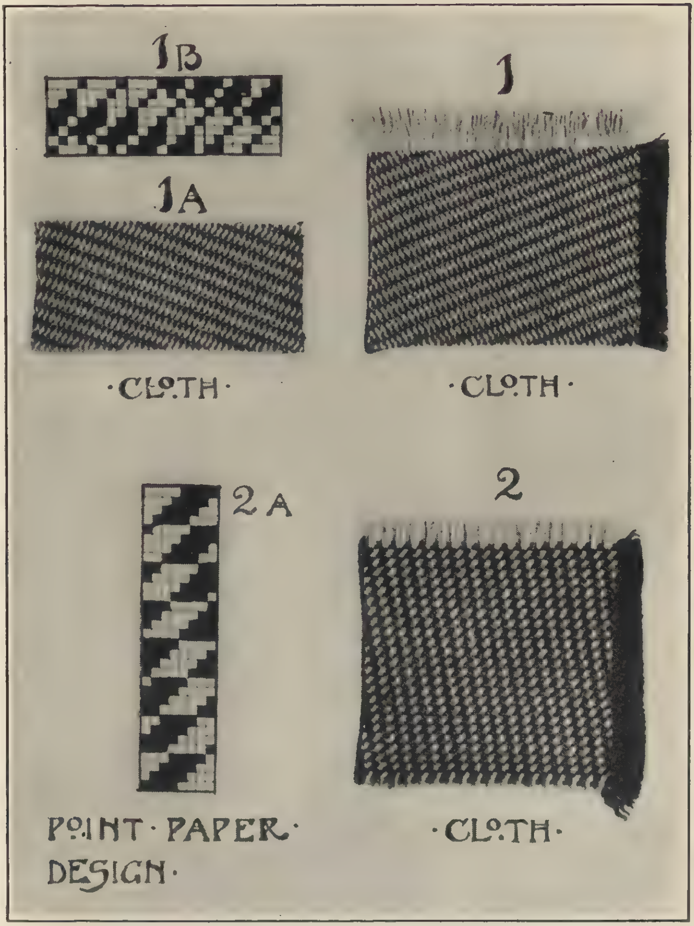
a. Introducing different weaves.
b. Using threads of different sizes in the weaves.
c. Using threads spun either to the right or to the left and using weft spun in one direction and warp spun in the other.
d. Using warp or weft spun so hard that the cloth crinkles or crepes on being released from the loom.
e. Combinations of the above.

II. Variations in coloring.

a. Loose fibers dyed before spinning.
b. Yarn dyed before weaving—dyed yarns used in weaving stripes, checks, and figures.
c. Cloth dyed in the piece after weaving.
d. Colors printed on the woven fabric.
e. Colors printed on the warp only.
f. Combinations of the above.

III. Variations due to finishing methods.

a. Degree of whiteness due to bleaching.
b. Napped surface—short or long.
c. Filled or weighted—variations in weight.
d. Loose.
e. Close.
f. Soft.
g. Stiff.



Standard weaves.

h. Elastic.
i. Dull.
j. Gloss or luster.
k. Moire.
l. Pressed.
m. Natural.
n. Crinkled effects.
o. Imitations of other textile fabrics, such as linen finish, silk finish, wool finish.
p. Special finishes, such as velvet finish, chinchilla finish, threadbare finish, worsted finish, unfinished worsted, etc.
q. Waterproofing—hard or soft finish.
r. Fireproofing.
s. Antiseptic finish.

Woven Structures.—The different kinds and makes of looms produce an almost infinite variety of weaves or woven structures. We are not now interested in the mechanical details of the different kinds of looms, but rather in their products, the kinds of cloth structures. In a general way all woven structures may be classified under the following groups:

1. Plain cloths.
2. Twills.
3. Satins or sateens.
4. Pile cloths.
5. Gauze or netting.
6. Double cloths.
7. Lappet weaves.
8. Figured cloths.

These structures can be made in all classes of textiles, cotton, wool, linen, and silk.

Directions for Studying Woven Structures.—In studying woven structures it is advisable for the student

to provide himself with a sample from each group mentioned, and to study it carefully, under a magnifying glass if possible, to make sure that the distinguishing characteristics of each class of woven structure are fully understood. He should pull the sample to pieces, a thread at a time, and should carefully note how the threads are interlaced; how the different threads compare in size; whether they are spun to the left or to the right, and so on. Note particularly the great change in the appearance of the cloth that results from what seems to be a very small matter in the arrangement of the threads. There is no other way in which to learn to know cloth except by studying cloth itself. All that this chapter can do is to point out what the student should look for. Those who are not regularly working in the textile trade should provide themselves with samples of all of the cloths mentioned, stitch or fasten them into a blank book, and then refer to them from time to time, reviewing the essential qualities of structure found in each. The test of good study of this subject will be the student's ability to tell what the structure or weave of a fabric really is; and he should be able to do this practically as soon as he sees and feels the cloth.

Plain weave.—In the plain cloths the warp and weft are regularly interlaced, alternating over and under throughout the cloth. For example, it will be found that every second warp thread is above the filling thread, while the alternate threads are below, and the positions of the warp threads are reversed for the next filling thread, and so on. The weft or filling threads run at right angles to the warp passing over and under each other in regular succession.

When the warp and the weft are of the same size, plain cloth presents an even, uniform appearance. If closely woven the surface will appear smooth. But smoothness also depends upon the character of the yarns. Some yarns tend to lie more closely together than others. Closeness of con-

tact of warp and weft is secured also by using warp spun in one direction and weft spun in the opposite direction. (The student should verify this statement by taking large-size twine or rope, one piece twisted to the left and the other to the right. By laying them at right angles across each other, just as warp and weft cross each other, he will see that they tend to sink into each other better than if they are both spun in the same direction.) As a result of the way the yarns are spun and the degree of hardness with which the cloth is woven, the cloths are either close or open in texture.

By varying the size of the threads of either the warp or the weft, a corded effect is produced. By using certain large-sized yarns at regular intervals, stripes, checks, and other patterns may be made.

Some of the common cotton plain cloths are calico, percale, gingham, muslin, batiste, cambric, challis, outing flannel, and cotton chiffon. The differences are largely in the size of yarns used and methods of coloring. To the above might be added such special varieties of cloth as sheetings, India linen, long cloth, mull, lawn, organdy, cotton voile, seersucker, shirting, etc. Among the plain weaves in wool goods are wool muslin, broadcloth, flannel, voile, nun's veiling, panama, woolen cloths, etc. In linens one may find linings, coatings, trouserings, and so on. In silks the plain weaves include taffeta, most of the foulards, and a number of other fabrics finished in several styles.

Showing the corded effects produced by using yarns of unequal size in the making of the cloth are poplin, piqué, whipcord, Bedford cord, plain repp, grosgrain, ottoman, faille, and several others.

Twill weaves.—In the twill weaves the threads or yarns do not pass over and under regularly as in the plain weaves previously described. Instead the threads are so woven together as to pass over one and under two, or over one

and under three, four, five, or six; or over two or three and under one, two, three or four. Besides these there may be several other combinations, more than can well be described here. The best way to get a clear idea of twill weaves is by the study of cloth actually woven in these ways. Most twills have a diagonal effect or appearance. This is produced by having the filling thread pass under and over a different set of warp threads each time. The order of interlacing for the regular diagonal twills is usually moved over one thread to the right, or to the left, with each filling thread that is woven. This results in the forming of the diagonal ridges on the surface of the cloth.

As with the plain weaves, a great number of variations are possible in the way of using yarns of different sizes, of different qualities, and of different colors. In fact there is much greater opportunity for variation in the twill weave than in the plain. For example, weavers can vary the direction of the diagonal lines to almost any angle. The lines can be made to curve, to wave, and to take other forms. When the direction of the diagonal lines is reversed at short intervals so as to form a zigzag line, the figure is known as "herringbone," because of its supposed likeness to the arrangement of the backbone in a herring.

The object of twill weaving is not simply that of producing more fancy and attractive fabrics than plain cloths, but also of making heavier and stronger cloth. Twills are almost invariably closer in texture than plain weaves.

In appearance, twills differ from plain weaves in that the surfaces are covered with diagonal lines running across the cloth. When these lines are very clearly marked the cloth is called diagonal rather than twill, but it should be remembered that diagonals are nothing but very clearly marked twills.

Some examples of cotton twills are jean, ticking, drilling, moleskin, canton flannel, twilled dimity, etc. Linen twills

include linen ticking, drilling, table and towel drills, marsella cloth, etc. Wool twills comprise serge, prunella, thibet, cashmere, merino, buckskin, etc. Among silk twills are silk serge, twill foulard, and silk croise.

Satin weaves.—The satin or sateen weave is a special form of the twill in which the principle of the twill is employed, but in which no trace of the twill structure, such as diagonal lines, is visible on the surface of the cloth. The result is a fabric, close in texture, with a smooth, glossy finish and generally a dull back.

By closely examining a piece of satin or sateen cloth, the student will find that the smooth, shiny surface is due to the fact that the threads lie parallel and close to each other and pass under the threads running at right angles only at intervals of six, seven, eight, and more cross threads. That is, the overshot threads pass for considerable distances before being crossed by the threads running in the opposite direction. The interlacing is managed at such irregular places and intervals in the cloth as to prevent any line or twill figure forming.

Satin weaves in cotton goods are frequent and numerous, but are generally called sateen or satine. Such goods are used extensively in making linings, night shirts, pajamas, and certain grades of work shirts. The heavier qualities are used for corsets, shoe linings, etc. Cotton is often mixed with silk in making satin weaves, threads being so arranged that most of the silk shows on the face while the cotton remains on the back. Such goods are often called cotton-back satins. Satin rhadame is another cotton-mixed silk satin. Atlas cloth is still another, but this is sometimes made up of cotton or even of linen alone.

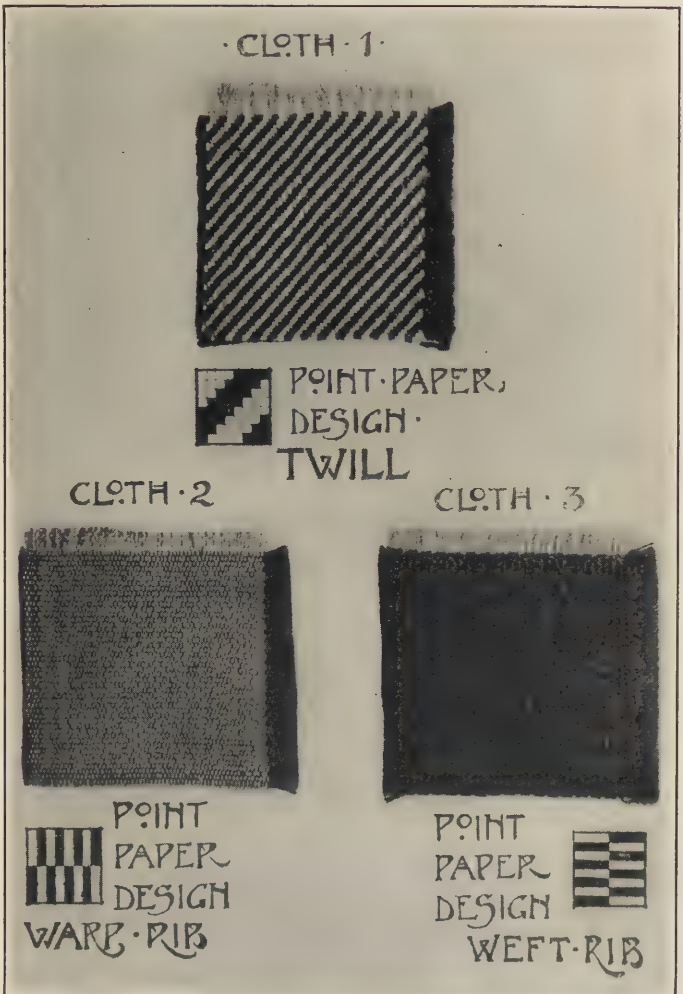
Linen is sometimes woven in satin weaves and, like cotton, is used for linings and other uses. Wool is worked up in the satin weaves for dress goods such as satin cloth or satin de laine.

In silk, however, satin weaves are most common. The peculiar quality of silk, its glossy, bright surface, gives it excellent appearance in the satins and satin-finished goods. Among the silk satins there are the ordinary satins; satin de Lyon, a twilled back satin often ornamented with hair or line stripes, and used for linings, especially in coat sleeves; satin de chine, a soft, fine fabric also used as lining; duchess satin, a fine quality of high luster and soft texture; satin foulard; marabout satin, smooth and fine, used in millinery; and sun satin, a ribbed or lined cloth also used in millinery.

Style fabrics in satin.—During the last few years satin-finished goods have had much popular favor. Several special variations have naturally been created, such as marveilleux, a satin-faced fabric showing a twill back; messaline, a soft, thin lustrous silk with a satin finish; satin charmeuse, a very rich appearing satin-finished fabric especially well suited to draping; satin crepe, a silk fabric combining the crepe feature with the satin weave; and crepe meteor, a silk fabric somewhat less brilliant than satin for the reason that the overshot is not so long. Crepe meteor has, in other words, a satin weave on a small scale.

Pile weaves.—Pile fabrics are characterized by having elastic fuzzy surfaces. This hairy or fuzzy surface is the particular part to which the name "the pile" is given. The commonest examples are velvet and plush. In those fabrics the pile consists of threads standing upright and all cut off evenly. In velvets these threads are shorter than in plushes; otherwise there is no difference. But there are other pile fabrics in which the pile consists of loops of threads instead of ends as in velvets and plush. Turkish toweling is an example of this kind.

During the last few years great progress has been made in the manufacture of plushes in which the pile resembles animal furs, as for example silk seal plush, broadtail or



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baby lamb, Persian lamb, Russian lamb, and pony skin.

Very light pile fabrics, such as chiffon plush, have come into considerable use for trimmings, millinery, and so on. With silk pile fabrics as with wool, cheaper textiles are generally introduced for backing. Velvets and plushes are so generally part cotton that a silk velvet should be considered as having a cotton back unless it is definitely stated that it is "silk backed." In carpet manufacture, the pile weave is very important. Brussels, Wilton, and tapestry are all pile fabrics, as the student may readily observe. Chenille cloth is a fabric with a pile on both surfaces.

Gauze weaves.—Gauze or netting is a form of weave produced on a special loom. The fabrics are very light and open, resembling lace. In fact, the progress in machine-made laces during the last few years has reduced the number of kinds of fancy nettings. The essential characteristic of gauze or netting is that in its construction, in addition to the regular sets of warp and weft threads used in a plain weave, extra threads, generally warp, are introduced which do not run parallel with the rest of the warp. These extra threads variously intertwine with the regular threads.

The commonest and simplest form of netting has an extra warp thread for every regular warp thread. The extra thread is wound around the regular thread as the weaving proceeds, a half-turn for every new filling thread inserted. This construction can easily be seen and studied in a piece of mosquito netting, where the threads and the mesh or openings between the threads are relatively coarse, and therefore easy to study. The weave found in mosquito netting and in the finer fabrics used for dress purposes, but of similarly simple construction, are known as leno weaves, and the looms making them are called leno looms. Nettings of various kinds are made from cotton, linen, wool, and silk and are used for light-weight gowns, flounces, window cur-

tains, and for many other purposes in dress and dress decoration.

Double-cloth weaves.—Double-cloth weaving is a process of making two cloths at the same time. Two sets of warp and of filling are used, but in the weaving process the two are attached by interlacing which makes the finished product a solid fabric. This construction is used in making heavy cloths such as heavy overcoatings, cloakings, pile fabrics, golf or Albert cloth, etc. This construction is also used where it is desired to use expensive textiles such as silk for the face and have considerable thickness or bulk back of it of cheaper materials. Many rich, heavy appearing silks are constructed in this way. In some instances this method of weaving is not limited to simply doubling the cloth, or making two-ply fabric as it is called, but is also used in making three-ply and even four-ply cloths. These weaves are especially serviceable in places where great strength and wear-resisting qualities are necessary as in cotton machinery belting.

The double-cloth weave is also used in making tubular cloths, such as pillow cases, pockets, seamless grain bags, etc. In these cases, however, the top and bottom fabrics are not connected as in regular double cloth.

Lappet weaves.—Lappet weaves are imitations of embroidery introduced into other weaves, such as plain or gauze. By means of a mechanical device on the loom, simple little designs are stitched into the warp, as, for instance, in dotted swiss, and certain narrow, continuous figures running into stripes or scrolls. Elaborate figures are not possible by this method of weaving.

Figured weaves.—Figured weaves are produced mainly by Jacquard looms, especially in making elaborate figuring. This loom is so devised that every warp thread is separately controlled and may be raised or lowered at the will of the operator or according to the design worked out before.

The control of the warp is made automatic by the use of pasteboard cards with holes punched in them corresponding to the design desired. In the loom the mechanical arrangement, similar to that of a piano player using paper record rolls, is guided by the perforations or holes in the cards, the proper warp threads are drawn up or let down, and the filling thread is shot through in the usual way.

There is practically no limit to the number of figures or designs possible on the Jacquard loom. It uses all kinds of textiles. It combines other types of weaves as a groundwork for the figures, and it uses yarns of many colors.

Cotton and linen damask are examples of figured weaving in the vegetable textiles. Wool damask, brocade, carpets, rugs, fancy vesting, etc., are common wool goods woven in Jacquard looms. But in the silks the greatest variety and qualities are to be found in damasks, brocades, broches, and brocatels. These figures, some flat, some raised, some sunken in the fabrics, are made on all sorts of regular weaves, plain, net, twill, satin, and pile. The goods are used for many purposes of a decorative character, for dress, upholstery, robes, hangings, carpets, etc.

CHAPTER XXI

DYEING AND PRINTING

Recent development of textile dyeing.—Nature riots in color. The dyeing process generally consists in taking some object of nature rich in a certain color, some plant, some animal substance, or some mineral, extracting the essential coloring substance therefrom, and then applying this coloring matter to the white or light-colored textile materials. During the last sixty years, however, there has been a great development in methods of extracting coloring substances from minerals, particularly from coal tar, a substance which in its crude state appears to contain none of the hundreds of beautiful colors, tints, and shades which chemical processes reveal. In fact, nearly all other coloring matters have lost ground before this new and powerful rival. Certain vegetable dyes of great importance in former days have been entirely replaced by coal-tar dyes.

The principle of dyeing.—The principle of dyeing can be simply stated. The coloring substances are mixed with some liquid, usually water, in proper proportions. Into this mixture, known as the dye liquor, the undyed textile is placed; whereupon the cloth or yarn becomes soaked with the dye. The coloring matter either fastens itself upon, or combines with, the textile in more or less permanent fashion. This transfer of the coloring matter from the dye liquor to the textile has been explained by the chemists as being caused by definite affinity or attraction between the dyes and the textiles.

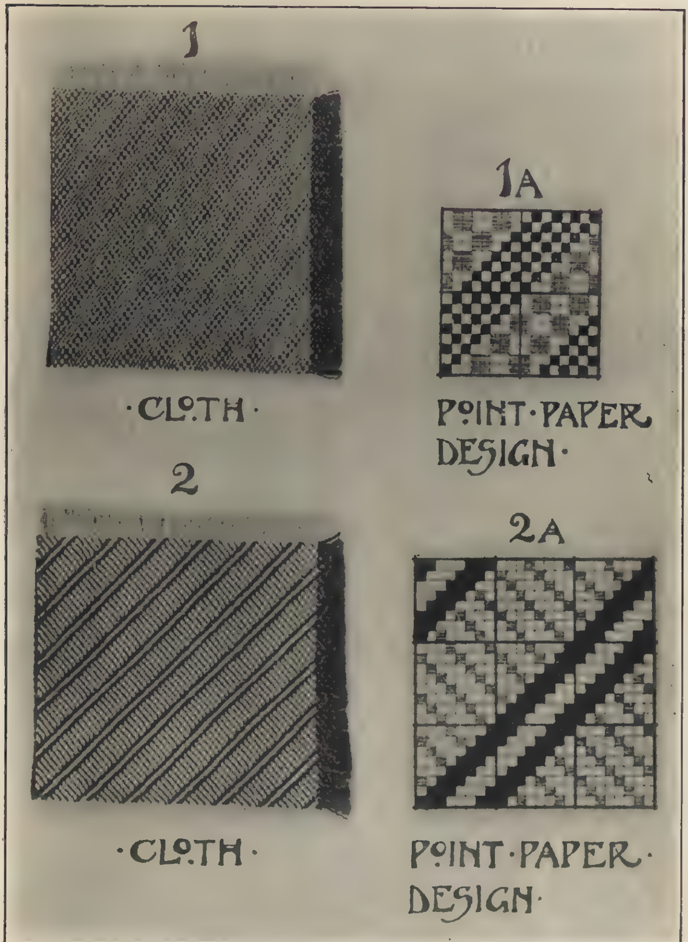
For the dyer a knowledge of chemistry is necessary. He must know of what chemical substances his textiles are composed, and for what other substances these textiles have affinities. With this knowledge he seeks the combination of dye materials that will give the color desired and at the same time have the proper attraction for the textile. The greatest difference exists between the animal fibers, wool and silk, and the vegetable fibers, cotton, linen, ramie, and so on. Wool attracts and takes a deep color from some substances that give cotton no more than a fleeting tint. The converse is equally true. Hence different textiles imperatively demand different dyes and different dyeing methods.

Production of fast colors.—The fastness of color so desirable in the textile fabrics depends solely upon the strength of the affinity between the textile and the coloring substance. Fastness to washing indicates that the affinity between the textile and the dye is stronger than any affinity that might exist between the dye and the water, or between the dye and the soapsuds. Perspiration affects the dyes in some fabrics; that is, there is a stronger affinity between the dye and perspiration than between the dye and the fabric, as a consequence of which the textile becomes discolored or fades. The oxygen in the air, especially in the sunlight, has a powerful affinity for many substances. Its power is demonstrated by the fading of many colors when exposed to air and sunlight. The active oxygen pulls the color out of the textile, leaving a sadly faded material.

Problems in the chemistry of dyeing.—The chemist in charge of the dye process must not only find the coloring matter that will give his textile material the right tint or shade and have a strong affinity for it, but he must also make sure that the affinity between the coloring matter and the textile is stronger than the affinity between that coloring matter and other substances with which it is likely to come

into contact, such as water, soap, light, air, and perspiration. He must, furthermore, consider how the requisite dyes and methods may be made applicable at reasonably low cost.

The processes through which the textile must pass and the purposes for which it is to be used are all considered by the chemist. For example, materials to be heated, steamed, washed, or scrubbed in the finishing processes must have dye materials in them that are not affected by these processes. Fabrics to be made up into underwear are not subjected to strong light as a rule, but must stand perspiration and washing in soapsuds. Hence the chemist selects dyes that have no affinity for perspiration, water, or soap when preparing dye materials for underwear goods. Cloth to be made up into shirts, aprons, house dresses, children's dresses, and similar uses must stand light, air, washing, and perspiration. Suitings that are not to be washed may be dyed so as to be fast to light and air, but not to water or soap. Fabrics intended for stylish evening wear need not be made fast to sunlight nor washing; therefore the happy chemist is free to concentrate his attention on producing a very brilliant or unusually delicate tint or shade. Formerly, hosiery for women was dyed to stand fast against washing, friction, and perspiration, but lately low shoes and high skirts have made it necessary to make hosiery colors fast to light also. Winter goods need not have colors so fast to light as must summer goods, for the winter light is far less bright and active. Goods for street wear are likely to be spattered with dust or mud. This street mud is likely to contain lime or other substances that may have a strong affinity for textile coloring matters; therefore such goods need dyes which are dust proof, mud proof, and shower proof. These are some of the many problems of the textile chemist in the modern dye works.



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COMMON DYESTUFFS

Natural dyes.—Let us now see what the common dyestuffs are. As already suggested, dyes are usually classified as natural or artificial. Natural dyes include such vegetable colors as logwood, indigo, fustic, cutch, butternut, sumac, madder, brazilwood, quercitron, safflower, sapanwood, peachwood, camwood, Persian berries, turmeric, saffron, henna, cudbear, and litmus. Cochineal, an insect, yields another natural dyestuff. Several minerals are used, as, for example, Prussian blue, chrome yellow, and iron buff.

The natural dyes are the oldest. The Bible has numerous references to colors and dyes; among them are descriptions of Joseph's coat of many colors, of the Tyrian purple, and other colors. All of these ancient color stuffs were natural; that is, they were extracted from plants, from animal substances, or from the earth. Oriental rugs were all dyed with vegetable dyes, some prepared by secret processes if we may believe the accounts of Oriental rug salesmen. Certainly some of the Eastern natural dyes were remarkable for brilliancy and for fastness under most of the conditions of ordinary use.

Up to sixty years ago only the natural dyes were used. But to people of today the list of dyestuffs named above is little more than a list of names. Most of those color substances passed out of use in the time of our grandmothers, and their places were taken one after another by artificial dyes, much cheaper, more easily applied, and, when properly selected and prepared, fully as fast as the natural dyes of old. Of the entire list only logwood is now used very considerably.

Artificial dyes.—Artificial dyes had their beginning in 1856, when an English chemist, H. W. Perkin, working with coal tar in his laboratory, accidentally discovered the

first coal-tar color, a beautiful mauve. A little later, a French chemist discovered the way of getting magenta by means of the same substance, coal tar. This turned the attention of color chemists the world over towards the new source of dyestuffs. A great number of experiments were made. In the last fifty years several hundred colors have been produced. Gradually the principles by which coal-tar colors can be extracted were developed, until they are now so well understood that the color chemist can sit down and work out in formula almost any color or tint with almost any desired fastness.

How Coal-tar Dyes Are Produced.—These colors, or aniline dyes, are derived from coal tar, a by-product from coal in the process of making coke. When coke is being made, it gives off a great deal of smoke and gas, which is all saved and reduced to the form of a liquor. This liquor is distilled, and the residue after the lighter oils are boiled off is coal tar. A like product is made from crude petroleum. Coal tar, as now known, is a very complex chemical substance, and a great variety of materials can be derived from it besides colors. From coal tar are made some of the most delicate artificial perfumes and flavors closely imitating, for example, wintergreen, violet, vanilla, and the fruits. From coal tar are made saccharine, a substance three hundred times as sweet as sugar, an artificial form of turpentine, substitutes for linseed oil, carbolic acid, salicylic acid used as a food preservative, naphthaline camphor, photographic developers such as hydroquinone and metol, creosote, vaseline, and a variety of lubricating oils. No one looking at the crude mass would ever guess its wonderful contents. Yet with coal tar as a raw material whole industries have sprung up within the last few years, among which the manufactories of textile dyes are probably the most important. Germany has led all the rest of the world in the manufacture of aniline dyes,

and it is due largely to the deep researches of German chemists that the great variety of colors and the excellent qualities of modern artificial dyes have been developed.

Early Failures in the Use of Coal-tar Dyes.—Soon after their discovery it was found that the coal-tar dyes differ greatly in their affinity for the different textiles. Early carelessness on the part of manufacturers was the cause of the general dissatisfaction with coal-tar dyes in the nineties. Dyes utterly unsuitable were used indiscriminately, with the easily foreseen result that many of them quickly faded. Coal-tar dyes are still suffering from the bad repute into which they came during these years, a reputation that it may take a generation of unfailingly good qualities to live down.

Discovery of Direct Cotton Dyes.—The colors first discovered were suited only to dyeing wool. A little later colors were produced which could be used on cotton by means of mixing with some other chemical having a strong affinity for cotton. In 1884, however, a direct coal-tar cotton dye was discovered, the so-called Congo red. After 1884, a whole flood of colors appeared. In 1885 there appeared a coal-tar color which had all of the chemical elements and qualities of indigo. This artificial indigo has practically taken the place of the natural color.

According to the chemical composition of these colors, they were grouped into various classes; for example, aniline, alizarine, benzidine, azo, sulphur, etc. There are now more than twenty such sub-classes in the coal-tar colors, each class containing a great number of colors, but each differing in behavior as a dye substance.

General classes of dyes.—Dyestuffs are now divided by dyers and chemists into the following large classes:

1. Acid dyes.
2. Basic dyes.
3. Direct or substantive cotton dyes.

4. Sulphur dyes.
5. Mordant dyes.
6. Vat dyes.
7. Developing dyes.

Other classes are sometimes given, such as the phthallic anhydride dyes, insoluble azo dyes, and some others, but the list given includes most dyes in common use. The names of these classes suggest something of the character of the dye or the method of application.

Acid dyes.—The acid dyes are what the name indicates. The number of artificial dyes in this class is very great, all characterized by being easily soluble in water and easily applied to cloth. Since these dyes have only slight affinity for cotton, they are not much used on that textile. Not all of the acid dyes are equally good for wool; some are very fast, while others are fleeting. According to one authority in textile chemistry, over seventy-five per cent of the dyed wools in the market are colored with acid dyes. To some extent, also, these acid dyes are used for dyeing silk.

Basic dyes.—Basic dyes differ from acid dyes in that they are basic in character and have the power of neutralizing acids. Basic dyes are the oldest among the artificial dyes. These dyes work well with wool because there are in the wool fibers certain acid properties with which the basic dyes combine easily. The combination is not usually very fast, however; hence basic dyes are passing out of use and giving place to more stable coloring substances. The basic dyes have no effect on cotton until the cotton has been treated with tannic acid. The basic dyes combine well with the tannic-acid-cotton combination, and the resulting colors are both brilliant and fast to light, water, and soap. Used in this way, the dye is called a mordant dye.

Direct dyes.—The direct or substantive cotton dyes origi-

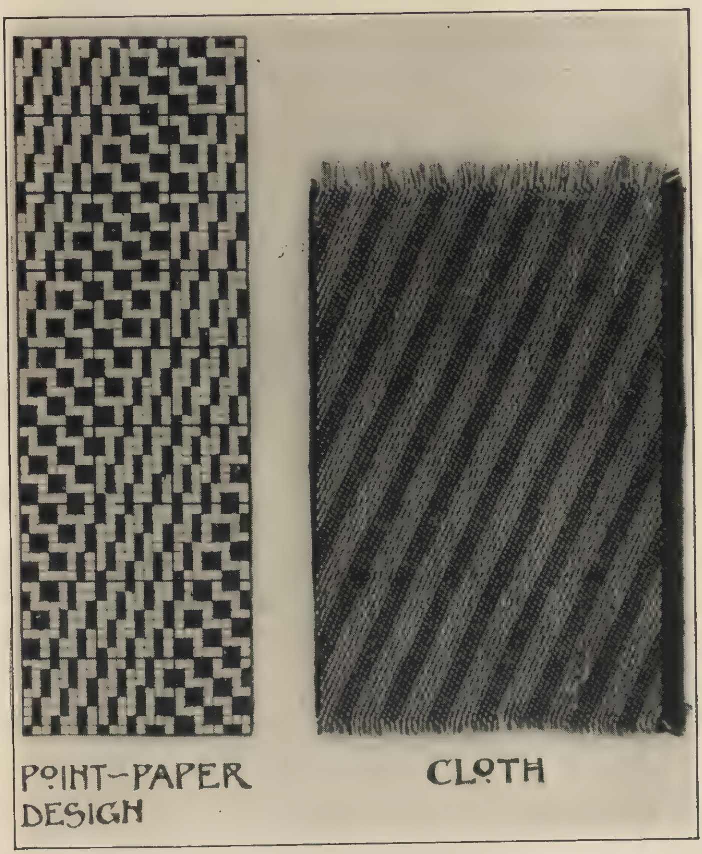
nated with Congo red in 1884. The peculiarity about these dyes is their affinity for cotton as a direct dye. There are now more colors and varieties of dye in this class than in any other. Practically every color has been developed in this class. These colors constituted a great textile discovery, saving much time and trouble in dyeing cottons. All that is necessary with a direct or substantive dye is to dissolve it in water, bring it to the temperature at which it works best, and then immerse the cotton cloth in the solution for a short time. Before this invention, cotton dyes, both of the natural and artificial varieties, had to be applied indirectly or with a mordant, that is, through the medium of a third substance, such as tannic acid, that had an affinity both for cotton and the dye substance. The discovery of the direct dye cheapened the dye process greatly, and shortened it too, a very important consideration when certain colors or patterns attain a seasonal vogue that cannot be foreseen and may be brief. The direct dyes vary greatly in fastness; many of them require that the dyed cloth be put through other solutions, such as copper sulphate or blue vitriol and water. Since 1902, however, a number of very fast direct dyes have been discovered and have largely supplanted all others for cotton goods. Direct dyes are also used on linen and, to a certain extent, on wool. The common household dyes that may be purchased in small packages, such as "Diamond Dyes," are of this class. The large dye-producing concerns of Germany have given to their direct dyes distinctive names which are well known to all commercial dyers. The Leopold Cassela Color Company call their colors "diamine colors." The Farben Fabriken Company uses the terms "benzo," "chloramine," and "katigen." The Badische Anilin & Soda Fabrik dyes are known as "pyramine," "oxamine," and "indanthrene," the last-named a remarkably fast series of colors, but not properly belonging to the class of direct dyes. The Amer-

ican Dyewood Company calls its dyes "tetrazo colors." The Berlin Anilin works denominate their dyes "Congo," "Columbia," and "Chicago." Several other brands besides these are used, most of which are, like these, of German manufacture.

Sulphur dyes.—The sulphur dyes contain sulphur in one form or another. Nearly all colors except reds have been produced in this chemical group. The sulphur blacks, blues, and browns are among the fastest produced. They are used only in cotton and other vegetable fabrics and are fast to light, washing, and acids, or perspiration. Sulphur colors are excellent for dyeing cotton hosiery and other knit goods in dark colors or blacks. Some of them require some after-treatment to fix them permanently in the fiber.

Mordant dyes.—Mordant colors are sometimes called adjective colors, because they are not applied directly but always through the means of some other substance applied to the textile first. Some substance or chemical called a mordant, having a strong affinity for both the textile and the coloring matter, is first applied. When the color is added, the result is a combination that may be expressed in the following manner: Textile + mordant + adjective dye = colored textile. The mordant clinging to the textile forms a combination with the dyestuff that dyers call a "color lake," a substance not soluble in water; hence it remains fast in the textile. Mordant dyes are the fastest known. They include most of the natural dyestuffs, such as logwood, cochineal, catechu, fustic (but not indigo), and a great number of artificial dyes. Uniforms for armies, navies, railroad companies, and large corporations are frequently finished with dyes of this class by contract specification. Very fast wool colors are obtained by means of mordants. Turkey red is an example of a cotton mordant dye.

The mordant substances include such acids as tannic



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acid, sumac, gall nuts, bark extracts, oleic and stearic acids, and Turkey red oil; and metallic substances such as various combinations or soluble salts of chromium, aluminum, iron, copper, and tin. The latter, the metallic mordants, are more used than the acid mordants.

Each mordant produces a different effect with each color. In general, tin produces the brightest colors and is therefore much used in fancy dress fabrics, in cotton, wool, or silk. Iron produces the fastest colors, but they are generally dark, as, for example, logwood blacks. Chromium is used extensively, especially for dark wool shades. The copper mordant also produces a fast dye.

Vat dyes.—Vat dyes include the natural dyestuff, indigo, and the artificial dyes called by the trade names, indanthrene, and flavanthrene. They are called vat dyes because, being originally insoluble in water, they undergo special preparation in large vats before the cloth is introduced; here they are made soluble, usually by the adding of caustic soda and hyposulphite. In this mixture or dye liquor the textiles are soaked. Certain chemicals are thereafter added, changing the dyestuff back to the insoluble form in the cloth or fiber. This is called the fixing process. All the vat dyes are fast, especially to washing. The artificial vat dyes have in many instances taken the places of the older mordant dyes, and their future seems promising, for they are cheaper and easier to apply than the mordants, although not so cheap and convenient as the direct dyes.

Developing dyes.—Developing dyes are color substances which, although they have some affinity for textiles, are not brought out in full hue until a developing process has been applied. One of the commonest developing agents is ice, or ice water. One of the best developing dyes is known as aniline black. It is one of the fastest and most beautiful. Sulphur blacks being cheaper have, however, taken the place of aniline black for most uses. Certain other chem-

icals are sometimes used as developing agents, but this group of dyes is not important and therefore requires no extended treatment here.

METHODS OF APPLYING DYES

Textiles are dyed in the form of the loose textile fiber, in the yarn, or in the woven fabric or piece. The products are known as fiber dyed, yarn dyed, and piece dyed, respectively. Most goods are either yarn or piece dyed. But for certain purposes it seems that dyeing the loose cotton or wool is the preferable method. Each method has special machinery designed for it, such as vats, kettles, and driers, but in principle the process is the same, depending wholly upon the kind of textile and the kind of dye.

The dye process.—The first step in any case is the thorough cleansing of the material by boiling and washing with caustic soda or hot soapsuds. This removes the dirt that may be found in the fiber. Often woven goods are bleached at this point, especially if they are to be dyed with light colors or tints.

In applying the mordant dyes to cotton fabrics, the next step is soaking the cloth in the mordant vats or kettles until the fabric is properly saturated. The cloth is then dried and hung up for two or three days in a moist air chamber. This is called the "aging" process, by means of which the mordants are firmly imbedded in the fiber. Next the fabric is passed through vats containing cow dung and chalk—the "dunging" process. After the cloth has soaked in these vats for an hour or two, it is raised, dried, and generally "dunged" a second time. The mordant is now firmly fixed. Substitutes for cow dung have been tried and are now widely used in the cotton-dyeing industry; none, however, gives more satisfactory results than the old-fashioned Eng-

lish dunging process. After the dunging the cloth is thoroughly washed and transferred to the dye vats. After the dye proper is absorbed by the fabric for such time as may be necessary to make the particular color wanted, the cloth is taken out, washed thoroughly, run through soapsuds, and washed again. To remove any foreign stains, the last washings may contain a little bleaching powder, but not

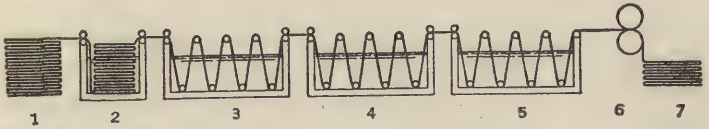


DIAGRAM OF CONTINUOUS DYE PROCESS

1. Piece goods from the looms or bleacheries.
2. Boiling off or washing process.
3. Rinsing box, cloth passed through running water.
4. Dye bath, direct dye application.
5. Rinsing box, cloth run through clean water.
6. Drying process.
7. Piece goods ready for finishing process.

enough to harm the dye itself. The cloths are then dried and made ready for the finishing processes.

CONTINUOUS DYE PROCESS.—The process of applying the direct dyes is naturally simpler. After the goods are washed and bleached, they are run directly into the dye liquor vats or baths, and by means of rollers kept in continuous motion through the dye liquor until properly dyed. The cloth then passes into a rinsing box, and the dye process is completed.

Printing.—There is another method of applying color to textiles, particularly to cloth, that is much used. This method is printing. The cloth is run through a printing machine supplied with rollers, one for each color to be printed on the fabric. These rollers are engraved with the designs desired on the cloth, and the cloth passing through them receives the impression of the engraved design in the

proper color or dye. The engraved rollers receive their coloring matter from troughs below or from regular inking rollers similar to those used in printing offices.

After the cloth has received the printed color impressions, it is passed on into a drying room; the dyes here become fixed in the fabric. This is followed by steaming, dunging, washing, soaping, and light bleaching, much the same as in the regular mordant dye process.

Printing Colors.—The dye materials used in printing are largely the same as those used in regular dyeing, except that they are applied in printing in the form of a thick paste instead of in the form of a liquid. Various substances such as starch, dextrin, tragacanth, and gum arabic are used as thickeners. In the case of the mordant dyes, both mordant and dyestuff are sometimes imprinted at the same time, but the results are usually less satisfactory than when they are separately applied. In some cases the mordant is applied in vats to the whole cloth as if it were all to be dyed, although the actual printing colors only the portion covered by the design.

Styles of Printing.—There are, then, as many methods of printing, "styles" of printing as they are called, as there are classes of dyes commonly used. Direct printing utilizes the direct dyes. The combined dyeing and printing method utilizes the mordant dyes. In addition to these styles, there are also what are known as the "discharge," the "resist" or "reserve," and the "topping" printing methods.

Discharge style.—The discharge style of printing consists in printing chemicals upon dyed fabrics in designs, the chemicals causing the dye to come out wherever applied, leaving the designs either white or in a different color from that of the dyed ground.

Resist style.—The resist or reserve style of printing obtains white figures on a colored ground by means of printing, before dyeing, with substances that are impervious to the

dye liquids. When these substances are thoroughly dried into the cloth, the cloth is dyed, but all portions covered with the resist paste or substances remain white. Countless variations are possible through the means of these different styles of printing and dyeing and through the use of various chemicals, printing pastes, dyes, and mordants.

Topping.—Topping printing is simply reprinting a fabric a second time after the colors from the first printing process have been fixed and dried. The first or ground colors applied are usually light in tint, while the topping colors are heavy, dark, or brilliant according to the demands of the dyer.

Uses of Printing.—The printing process is used most extensively in coloring cotton fabrics. Cotton prints such as calicoes occupy an important place in the textile world. Wool and silk are also sometimes printed. In silks especially many beautiful patterns are obtained by means of printing. Yarns are sometimes printed before they are woven, particularly the warp. This gives the effect of an indistinct design in the finished fabric. The fiber is also printed sometimes before it is made into yarn, while in the combed sliver stage in worsted manufacturing. Printing on combed sliver is called "vigoureux printing."

Factors affecting success of dyeing.—Several factors affect the success of the dyeing industry. The necessity for technical and chemical knowledge has already been emphasized. But there are also certain requirements as to environment, such as pure water, air free from factory smoke, blast-furnace smoke, or sulphur fumes, and so on.

Pure Water.—The importance of pure water is very great, since any lurking chemical dissolved in the water—lime, for instance—would upset all of the chemist's calculations, would cause the same dyestuffs to give different results or fast dyes to become fleeting, and, in some cases, would prevent absorption of the dye at all. Hence dye-

houses are usually located in regions where the water is very pure and soft, and, besides this, pains are taken still further to purify the water by removing any lime, sulphur, iron, or other minute mineral matters which may be found dissolved therein. It is noteworthy that much home dyeing fails, even when the dye recipes are closely followed, simply because of some chemical impurity in the water used to dissolve the dye substance.

Differences in Fibers.—Another thing the dyer must consider is the particular variety of cotton, of wool, or of silk that he is to color. No two varieties absorb the colors in the same way or to the same extent. For example, India cottons take a deeper shade, under the same conditions, than American cottons. A stronger solution, or a longer soaking, is necessary for the American cottons than for the India cottons. In addition, there are minor differences in the fibers from different localities, perhaps because of differences in soil, rainfall, temperature, and care received during the growing season. Similar differences are also to be noted in wool and silk, especially in the latter. Silk dyers in Europe always desire to know the source of the silk before they prepare to dye it.

CHAPTER XXII

CLOTH FINISHING

Importance of cloth finishing.—Cloth finishing is one of the chief arts in the textile industry. The appearance of the goods is often of first concern, and the appearance of any fabric is largely due to the methods of finishing.

BLEACHING

Bleaching is one of the most usual and important among the finishing processes. It has for its object the whitening or decolorizing of the textile fiber to which it is applied. Fibers, as they come from the plant, from the back of the sheep, or from the cocoon, are usually somewhat colored or stained. Some of them, like tussah silk or Egyptian cotton, are highly colored. This natural coloring of the fiber may be undesirable in many fabrics; hence, bleaching is employed to clear the fiber of this color. Again, most fibers accumulate stains of various kinds during the early processes of manufacture as, for example, in the spinning and weaving. This discoloration cannot be entirely removed by simple washing; hence, the bleaching process is applied to clear the fabric. In like manner, when the calicoes or other prints come from the printers, the white background between the colored figures may be soiled, spotted, or otherwise discolored; again, a light bleach is applied, but not enough appreciably to injure the color in the figures.

Bleaching agents.—There are two classes of bleaching substances, oxygen and sulphurous acid. Under certain conditions oxygen destroys the coloring matters entirely. Sulphurous acid probably does no more than change the color to white, leaving the coloring substances still in the textile. An object once bleached white by oxygen is not likely to turn yellow or to change back to its original color; whereas textiles bleached in sulphurous acid quite frequently do change back again after a time, especially when in contact with certain chemicals such as alkalies or soaps.

Grassing.—The oldest bleaching method is that of "grassing," still used to a certain extent in Europe for bleaching linens. The linen fabrics are laid on the grass or ground for weeks. The oxygen of the air and that given off by green plants slowly attacks and destroys the little yellow color particles in the flax fiber. Slowly the linen becomes whiter and whiter until finally it is fully bleached. The particular value of the grass bleach over all others is its slowness. This guarantees permanence. Furthermore, the "grassing" process is not likely to be carried on a bit further than necessary. The oxygen which attacks the coloring matter may ultimately attack the cellulose in the fiber and does do so in chemical bleacheries unless the fabric is removed at the proper time. A few moments' delay, therefore, in a chemical bleachery means great damage to the cloth; whereas a few days either one way or the other in grass bleaching makes practically no difference. Cotton also was at one time bleached in this manner, but the more rapid chemical oxygen bleachers have entirely superseded grass bleaching for this textile.

Chemical bleaching.—The principal chemicals used in oxygen bleaching are chloride of lime, hydrogen peroxide, sodium peroxide, and potassium permanganate. All these substances are heavily charged with oxygen. In the bleaching process, this oxygen is set free, and this free oxygen

attacks the coloring matters in unbleached goods. The bleaching powder of commerce is chloride of lime, the principal bleaching substance used for cotton and for all other vegetable fibers excepting jute. It is, however, entirely unsuitable for wool and silk. Hydrogen peroxide is the best bleaching substance of all. It may be used on any sort of fiber, for it attacks nothing but the coloring matter. It is frequently used in removing stains and also in bleaching hair. But for general textile bleaching purposes it is too expensive, and is hard to keep in concentrated form for even a short time. It is used extensively, however, in bleaching wool mousselines that are to be printed. Hydrogen peroxide produces a much better result than sulphurous acid, the common bleaching substance for wool. When cheaper means of producing peroxide are discovered, this chemical is bound to take front rank among the bleaching agents. Potassium permanganate is another oxygen-loaded chemical that is sometimes used in bleaching woolens. Sodium peroxide is a compound somewhat cheaper to produce than hydrogen peroxide, and contains a large amount of live, active oxygen. It is a rather new bleaching agent, but is already used to a certain extent on wool and silk, especially tussah silk.

Sulphur bleach.—Sulphurous acid bleach is applied in the form of either a gas or a liquid. The gas is produced by burning sulphur in the air. The fumes that arise from burning sulphur are sulphurous acid gas. The liquid is produced by saturating water with this gas. Sulphur bleach is used mainly for animal fibers (wool and silk) and jute. The most common method employs the gas rather than the liquid. Rooms called sulphur chambers are built out of brick especially for this purpose. The fabric or yarn is brought into this chamber and hung up damp in loose folds while sulphur is burned in pots on the floor. The rising fumes saturate the damp textiles, the dampness materially

assisting, and the fibers gradually whiten. In large wool bleacheries the cloth is run through the sulphur chamber on rollers, bleaching on the way. The process is inexpensive and results in a beautiful white. Its tendency to make wool harsh is corrected by washing in soap and water. When the wool is mixed with cotton there is danger of the cotton's being destroyed by the acid. The sulphur bleach is ordinarily used for wool and silk.

Chloride of lime.—In cotton bleaching, chloride of lime is the most common chemical used. Cotton is generally bleached in the piece or fabric form. The usual exceptions are sewing cotton, absorbent cotton, and jeweler's cotton. The last two are bleached in the state of loose fibers. When the cotton comes from the looms it is still in the natural color, although somewhat altered by the sizing in the warp and by the dirt, grease, and dust accumulated in the machinery. The cloth is now said to be "in the gray." It is, however, more of a dirty yellow than gray, and presents a soft, flabby, fuzzy, unattractive appearance. It is now ready for the bleaching process.

The bleaching process.—The cloth is first run through a washing machine to remove as much of the discoloration and dirt as possible. Next, most fabrics are either sheared or singed; that is, they are run through machines which either cut off or burn off the fuzziness that is always found on cloth direct from the loom. The shearing process is performed by a machine that works on the same principle as a lawn mower, cutting all loose ends and fibers very close to the body of the cloth. The singeing is done by very quickly passing the cloth over a line of gas jets, or over a red-hot plate, where the heat burns off the fuzz but has no time to burn the fabric itself. Recently, singeing has been successfully performed by electricity. Cloth is sometimes singed on both sides, sometimes on only one. The shearing and singeing processes leave the cloth apparently smooth.

As a rule, cotton cloths are then bleached. There are four common methods, or "bleachers" as they are called: "madder bleach," "Turkey red bleach," "market bleach," and "rapid bleach." Of these the madder bleach is the most thorough. The others differ from the madder bleach mainly in degree of thoroughness. Goods to be dyed in deep colors need less whitening; hence, they are given, for example, the Turkey red bleach. Goods to be dyed black need almost no bleaching; for these the rapid bleach is sufficient. The market bleach is really the rapid bleach with the addition of blueing and other substances to cover up defects in the process.

The bleaching industry.—Cotton bleaching is often conducted as a separate industry. In England this is quite the rule. The cloth is sent from the weaving concerns to the bleacheries to be bleached on commission or at so much a yard. Sometimes the products of the loom are purchased by converters who hire others to do all the finishing processes, including bleaching. Occasionally bleachers buy the cloth in the gray, bleach it, and again market it. In this country bleaching and dyeing works are usually associated, and both are frequently under the same management as the cotton mills. This joining together or integration of related industries is typical of American business organization, not only in the textile industries, but also in many other great businesses, such as steel production and meat packing.

How the bleacheries handle cotton goods.—Piece goods arrive at the bleacheries in bolts or rolls of an average length of fifty yards. Each of these is stamped with the owner's name, the length of the bolt, and other necessary particulars. The ends of several hundred rolls are first stitched together to form one long sheet sometimes as much as twenty-five miles long.

Moistening and bowking.—When all is ready, the cloth is moistened, run through a six- to eight-inch ring to rumple

it and form it into the shape of a rope, and in this form it is laid away in coils for several hours in bins to soften the sizing in the warp. Next, the cloth is turned into a covered tank called a kier, in which is a weak solution of caustic soda or milk of lime. The liquid is kept moving through the tank by means of pumps. Here the cloth is stirred for about eight or ten hours, a process which removes all fats and wax found in the cloth, such, for example, as the natural wax found around the cotton fibers. All of this must be thoroughly removed before bleaching if the cloth is to be made snow white. The mixture in the "kier" is called the "lime boil," and this particular part of the process is called "bowking." The process concludes with a thorough washing in pure, fresh water.

Brown sour.—The next step, known variously as the "brown sour," "gray sour," or "lime sour," follows the washing. The cloth is passed into tanks of water containing sulphuric or hydrochloric acid, sometimes both. This souring process counteracts the action of any caustic soda or lime that may remain in the cotton fiber from the previous treatment. Here a knowledge of the chemistry of bleaching is absolutely essential. The proportion of acid in the "brown sour" must be just sufficient to destroy the alkali in the fiber. If not strong enough, the alkali will not all be destroyed and will continue to cause trouble throughout the entire life of the cloth. If too much acid is used, then not only will the alkali be destroyed, but the cotton fiber will be endangered as well. Much of the poor cotton cloth in the market owes its lack of strength to poor bleaching methods. Linen is more sensitive to these chemical changes than cotton; hence the difficulty of getting good chemically bleached linens. The acid or souring bath is followed by a washing in pure water.

Lye boil.—In the full madder bleach the cloth after the acid bath is usually passed into a second alkali bath con-

taining hot lye and resin soap. This is called the "lye boil." After three hours of boiling under pressure, with the alkali liquor forced through every part of the cloth by means of pumps, all of the fats and acids in the fiber have been extracted and changed into soapsuds. The invariable washing in pure water follows.

Chemicking.—The cloth is now ready to be transferred into the real bleaching bath, the chloride of lime solution, or "chemick," as bleachers name it. Through this bath the cloth is passed back and forth, the liquid being forced

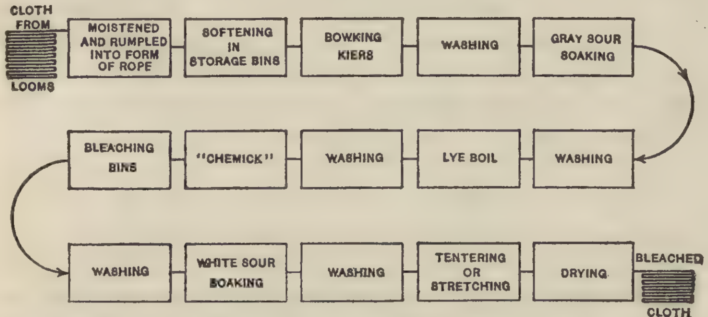


Diagram of Processes in the Full Madder Bleach.

through every part of it. After one or two hours this part of the process is completed. The cloth is removed and passed between heavy wooden rollers, which press out the excess of the chloride of lime solution. The cloth is then coiled or piled in bins so as to be exposed to the air. It is here that the real bleaching takes place. The chloride of lime absorbed in the fiber has a strong affinity for air and for water. Both are attracted, and in the chemical processes that follow a certain amount of oxygen is crowded out of the air and water, and this free, active oxygen attacks the coloring matters and destroys them. Now again the proportions must be scrupulously adjusted so that not too much or too little oxygen is produced. Too much

would result in an oxidation or destruction not only of the color particles, but also of the cotton fiber itself.

White souring.—The chemicking or bleaching is followed by washing in pure water and afterward by treatment in a weak acid bath known as the "white sour." In this bath all action of the chloride of lime is stopped. Then follows another most careful washing in water to remove every particle of acid, whereupon the bleaching process is ended. The cloth is opened up flat, spread out, beaten, stretched or tentered, and dried over hot rollers. It is now ready for dyeing, for printing, for mercerizing, or, if to remain in the white, for the final finishing processes of sizing and calendering. Dyeing, printing, and mercerizing have already been described; hence, we need only give our attention to the final finishing processes.

CLOTH DRESSING

Whether the cloth shall be made soft or stiff, dull or glossy, and so on, depends upon the finish applied and the materials used. Certain sizings fill up the spaces between the threads in the fabric, stiffen the fabric, and give it greater weight and body. Other sizing materials give stiffness without adding weight. Some give weight without stiffness. Some help to make the fabric glossy, others to give the cloth some special appearance in imitation of a different fiber. It would take a volume to give in detail an account of how these various effects are obtained. Such a description is not necessary here. A fair idea of the possibilities of cloth finishing can be obtained by a study of fabrics themselves, especially with the help of a small magnifying glass and with such tests as boiling and rubbing.

Dressing materials.—The materials used in cotton finishing or dressing include starches, glue, fats, casein, gelatin,

gluten, minerals, and antiseptic substances. The starches give stiffness and weight; glue gives tenacity to the starches and other materials. Minerals, such as clay, are used to give weight. Fats give the qualities of softness and help make the fabric more elastic. Wax, stearin, and paraffin are frequently used to develop a high luster in the calendering or pressing processes. Antiseptic substances such as zinc chloride, salicylic acid, and zinc sulphate are added to prevent the starches and fats used in the dressing from molding or putrefying.

Starches.—The starchy substances commonly used include wheat flour, wheat starch, potato starch, rice starch, and cornstarch. Sometimes the starch is baked until brown before using. In this form it is called dextrin or British gum. Dextrin gives a softer dressing than any other starchy material. Wheat and corn starches produce the stiffest effects. Potato starch comes between the two extremes. Starch is sometimes treated for a couple of hours with caustic soda at about the freezing point. At the end of this time the excess of alkali is neutralized with acid. The result is a gum, called apparatine, which stiffens the cloth and does not wash out so easily as most other stiffening substances. Starch treated with acid produces glucose, and this is used largely as a weighting or loading material.

Fats.—Among the fats used are tallow, stearin, several different kinds of oils and waxes, and paraffin. These are sometimes added to the starches to reduce the stiffness of the fabrics. Glycerin and magnesium chloride are frequently added for the same reason. Fats may be added to waterproof the cloth, although waterproofing is usually accomplished by rubberizing; that is, by soaking the cloth in a solution of crude rubber or caoutchouc.

Minerals.—The minerals are added for various reasons. China clay increases the weight as do also salts of lime and

baryta. Alum, acetate of lead, and sulphate of lead are sometimes used. Adding large proportions of borax, ammonium phosphate, salts of magnesia, and sodium tungstate makes the fabric fireproof.

How the dressing is applied.—The dressing material is usually applied as a liquid paste to the back of the cloth and then run over hot rolls or cylinders in order to dry the paste quickly. Sometimes it is applied lightly to the surface, sometimes it is pressed in deeply by means of rollers. When both sides are dressed, the fabric is passed into and through the dressing material. When the cloth is dry, the sizing or dressing process is complete. If merely a dull, hard finish is desired, nothing further is necessary except to stretch and smooth out the cloth, measure, bolt, and press it. But if any kind of polish is demanded, then the cloth must be calendered, pressed, mangled, or ironed.

CALENDERING

Calendering is accomplished by passing the cloth between large rolls, from two to six, under heavy pressure. In the rolls the dressing is smoothed out, and the hard, dull finish becomes soft and glossy in appearance. Heated rolls give a better gloss. When the rolls are made to turn over each other at different rates, there is a heavy friction or ironing effect on the cloth. For the highest glosses not only starch but also fats and waxes are used, and all are ironed into the cloth under heavy pressure and at as great heat as the cloth will stand. When calendered the fabrics are usually dampened first, just as clothes are dampened by the housewife before she irons them. The dampening in a cloth-finishing plant is done by a special machine that sprays the cloth very evenly as it passes through.

The beetle finish.—There are several special finishes pos-

sible through variations in the calendering process. Beetling is one of these methods. The cloth is passed into a machine over wooden rollers and beaten by wooden hammers operated by the machine. The beetle finish gives to cotton or linen an appearance almost like satin and is very beautiful.

Watered effects.—Moiré or watered effects are produced by pressing some parts of the threads in a fabric down flat while leaving the other parts of the threads in their natural or round condition. The effect is usually that of an indistinct pattern. It is obtained in different ways, sometimes by running the cloth through the calender double, or again by running the single fabric between rollers especially engraved with moiré designs. Only soft fabrics are suited to this finish; hence, no dressing except fats is used for moiré goods.

Embossing.—Soft fabrics are sometimes stamped with patterns in the manner of embossing by means of engraved calender rolls. This process is called stamping.

Schreiner finish.—Another special finish, known as "Schreiner finish," is applied in the calendering operation by passing the cloth between rolls covered with great numbers of finely engraved lines. The number often runs as high as six hundred to the inch. Under a pressure of 4,500 pounds these lines are pressed into the fabric. The result is that the round threads are pressed flat, but the lines break up the flat surfaces into little planes that reflect the light much better than an ordinary flat surface would. This peculiar light reflection gives the cloth the quality of a very high luster. Heating the rolls makes this luster more lasting. The effect is very beautiful. Mercerized cotton finished in the Schreiner finish rivals silk in appearance.

Most of the finishes spoken of so far, the result of dressing and calendering, are easily destroyed. Wear destroys any of them in time. Washing destroys most of

them. But as long as they last they are highly important elements in the appearance of the fabrics.

OTHER FINISHING PROCESSES

Dressings applied to the various textiles.—Dressings are usually applied in much greater quantity to cotton than to any other textile. Linen comes second, and the principal dressing substance used in linens is starch. Glue, gelatin, dextrin, albumen, and water glass are applied under certain conditions and for certain effects in woolen goods. The common weighting materials added to woolens are short hairs or short wool fibers, sometimes called flocks. Flocks are the ends of fibers sheared off from the surface of wool or worsted cloth. Woolen cloths are padded or impregnated with these in the fulling mills, sometimes adding from one-fourth to three-fourths to the weight of the wool. Such finishing processes as beetling, mangling, moiréing, and stamping are never applied to woolens. Silk usually has very little dressing applied to it in the finishing process, and that little generally consists of gelatin, gum arabic, or tragacanth. The other finishing processes are very much the same for silk as they are for cotton.

Lisle finish.—Several other finishes, or modifications of the finishes just described, are used in cotton goods when it is desired to show special effects. The lisle finish is given yarns that are to be used in the manufacture of hosiery and underwear. The true lisle finish is obtained by using combed, long-stapled, sea-island or Egyptian cotton. The yarns made from these fibers are rapidly but repeatedly run through gas flames until they are entirely free from any projecting fiber ends or fuzz. The result is a very smooth, glossy thread. Another kind of lisle finish is obtainable in a finished fabric, as, for example, in hosiery, by treating with

a weak solution of sulphuric or hydrochloric acid and then drying before washing out the acid. The goods are afterward tumbled around in a machine that exposes them to the air and heats them to about 100 degrees Fahrenheit. After a time the loose ends and fuzzy fibers become brittle and break off in the tumbling given the goods. When the goods present the proper lisle finish, they are cooled off and washed in an alkaline bath which stops the action of the dry acid and neutralizes it. After thorough washing in clean water, they are dried and are ready for dyeing or any other finishing process. Sometimes the acids are added to the dye bath to cause more speedily the same effect in the appearance of the goods. Some dyes are regularly made up with the acid mixture.

Wool finishing.—The finishing processes for woolens and worsteds are much more laborious and complex than those employed for cottons. A greater variety of machinery is required, and there are more steps in the process. The finishing of wool goods is divided into two main parts: the first is called the "wet finishing," which includes washing, soaping, steaming, carbonizing, and the use of liquids; the second is called "dry finishing" and includes napping, shearing, polishing, measuring, and putting up in rolls or bolts.

Preparation of wool fabrics.—Woolen or worsted cloth, as it comes from the weave rooms to the finishers, is first inspected for flaws, broken threads, and weak places, and wherever these are found, chalk marks are made to assist the burlers and menders in finding the places. To aid in the inspection, the cloth is generally "perched" or thrown over a roller and drawn down in single thickness by the inspector as fast as he can look it over. A good light is desirable. Inspectors with practice attain great proficiency in finding weak places or imperfections in the cloth. After the bad spots in the fabric are repaired the goods are tacked together; that is, the pieces are fastened together in pairs

with the faces of the cloth turned towards each other. The tacking is simply a stitching along the edge, done either by hand or machine. The purpose of tacking is to protect the faces of the cloth from becoming damaged in any way by the heavy operations to follow or from becoming impregnated with any foreign substance difficult to remove, such as short hairs or flocks.

Fulling.—The next step is the fulling. All kinds of clear-finished worsted dress goods for ladies and practically all wool cloths for men's wear except worsteds are fulled. This is the most characteristic process in the wool industry; no other textile goes through any process like it. The wool fibers, it will be recalled, are jointed and have scales that cause the fibers to cling together readily. This, we have learned, is called the felting quality. By beating a mass of wool fibers, a very hard, compact mass can be obtained, because the fibers creep into closer and closer contact with each other, holding fast because of the scales. Fulling makes use of this principle. Wool cloth is shrunken and made heavier and closer in structure and consequently stronger. Fulled cloth may also take many more kinds of finish than unfulled fabrics. The fulling process is performed in machines that apply pressure, moisture, and heat to the goods. The cloths are soaked in hot, soapy water, pressed, rolled, and tumbled; as a result, the woolen fabrics contract and become closer in texture throughout.

Flocking.—Short wool fibers or flocks are frequently felted into wool fabrics in the fulling operation. A layer of these short fibers is spread over the back of the cloth and matted down by moistening. In the fulling operation these fibers sink into the fabric and therefore help to give the fabric weight and closeness. That this process is not always well done is evidenced by the fact that the flocks in the backs of suitings often wear loose, drop down, and collect at the bottom of garments, especially at points

where the lining and the suiting are sewed together. Flocks must from most standpoints be considered as an adulteration of wool although their presence really helps some fabrics, such as kerseys. All crevices are filled up and the fabric is made solid. If the felting has been done well, the flocks perform a good service in the cloth, but otherwise the flocks come out easily and are a decided nuisance to the wearer of the goods. Flocks made from wool waste such as shoddy, mungo, and extract, when applied on shoddy wool cloth are bound to come out. But flocks cut from new wool, when applied to new wool cloth, produce an excellent effect if not too largely used. Adding 25 per cent in weight to the cloth by flocking is not unreasonable, but doubling the weight of the original fabric would be unjustifiable adulteration. Flocking adds little if any to the strength of the cloth.

Speck dyeing.—After fulling, the cloth is washed very carefully, and is usually given a light dye to cover up spots or imperfections due to foreign matter that could not be taken out before. If not so dyed, all the little specks in the cloth have to be removed by hand, a process called speck dyeing or burr dyeing.

Carbonizing.—Carbonizing is usually performed before the wool is spun into yarn, but in some cases not until the cloth is woven. In this case it takes the place of speck dyeing. The process is the same for cloth as for loose wool. The vegetable matter is destroyed by soaking the cloth in weak acids and then heating in an oven.

Napping.—After washing, stretching, and drying, most goods are ready to receive the finish. In most cases this first involves raising a nap or fuzz evenly all over the surface, and for this purpose machines have been invented. The oldest of such machines use teasel or thistle burrs, whereas the later napping machines use little wire hooks. Some claim that the teasel burr has certain qualities for

raising the wool nap that cannot be produced in any steel wire or spring hook or barb. The principle, however, is the same in all inventions for this purpose. The gigs or napping machines all stretch the cloth and then cause it to pass over many fine little hooks of teasel burrs or of steel wire which draw out a multitude of little ends of wool fiber all over the surface of the cloth. In some cases, the napping or gigging is performed on wet cloth; in others, the cloth is dry. Dry napping is in fact now the more common, although the wet methods are still employed for certain cloths and finishes.

The finish of wool cloth depends upon the *degree of napping* and upon the *variety* of fiber. Meltons require only a little napping; kerseys, beavers, and doeskins, a very thorough one. Cloths that must wear exceedingly well must be napped as little as possible, since the process reduces the strength of the fabric. Cassimeres are given several kinds of finish, Saxony finish, for example, or velour finish. Other fabrics are each given their characteristic finish by slightly varying the amount of nap, or the treatment of the nap after it has been raised. Among such fabrics are cheviots, kerseys, meltons, beavers, chinchillas, outing flannels, doeskins, reversibles, thibets, satinets, blankets, and others.

Lustering.—After napping, such fabrics as kerseys, beavers, broadcloths, thibets, venetians, tricots, plushes, uniform cloths, and all worsteds, require another special operation known as steam lustering. Steam is forced through the cloth for about five minutes, followed by cold water. The steam brings out the luster which the cold water sets or fixes.

Stretching and clipping.—The dry finishing processes begin with stretching (or tentering) and then drying the cloth. Special machines accomplish this as well as all the other processes. The cloth now passes through a shearing machine which brushes the nap in the direction desired, after-

ward clipping it evenly over all the surfaces. The clippers operate like the revolving blades of a lawn mower. Goods that have not been napped are generally singed in much the same manner as cotton fabrics. Next, the sheared fabrics are brushed, and perhaps polished by means of pumice cloth or sandpaper, to make the cloth smooth and lustrous.

Final steps.—Finally the goods are pressed and thereby given a finished appearance. This is usually performed by means of heavy presses, either with dry heat or with steam. The most common present-day method of pressing cloth is by running it between heavy rollers heated by steam. Care must be taken not to get the rolls too hot or the wool will be damaged. The cloth is next inspected again, run through a measuring machine, doubled, rolled, and wrapped in paper, and packed into cases ready for the clothing manufacturer or the dry goods jobber and the retail store.

Worsted finishing.—Worsteds are not generally fulled as are woolens. After burling, worsteds are usually singed and then crabbed. The crabbing process sets the weave so that in the later operations it will not be obliterated. It consists in running the cloth tightly stretched over rollers through a trough containing hot water. After an hour or two of this the cloth is scoured and rinsed and then closely sheared. There are several varieties of worsted, each of which requires its own special finish or after-treatment. Innovations are constantly introduced to alter the appearance a little in one way or another. Among these are the fancy or yarn-dyed worsteds, serges, worsted dress goods, and worsted cheviots.

CHAPTER XXIII

THE CARE OF TEXTILES

Importance of proper care.—Not a small share of the dissatisfaction that arises among consumers of textiles regarding specific fabrics is due to lack of proper care of the cloth. Each textile has its own constitution and therefore needs its special attention. Linen must be treated differently from cotton, and both in turn must receive a care quite different from that needed by wool. Silk calls for still different care. A textile fabric cannot be expected to give its fullest service unless cared for according to its specific qualities.

GENERAL DIRECTIONS FOR CARE OF TEXTILES

Certain general observations concerning the care of textiles are applicable to all alike; these we shall first note. Such little attentions as keeping garments and fabrics free from dust by frequent brushings are matters of everyday knowledge by all, but are by no means always observed. Nor is the danger from dust clearly understood. If dust were simply dead, inert matter as it seems to the eye, there would be little danger of loss from letting garments and cloths go undusted for some time. But dust, unfortunately, usually contains great numbers of little germs, living organisms, that fly about with currents of air, seeking food and resting places. It so happens that the textile fibers are

excellent foods for some of these germs. Leaving the dust on a garment may mean leaving some of these hungry and industrious little germs which attach themselves upon a fabric and multiply at a very rapid rate, soon covering entire spots if not whole garments. When this has occurred, no amount of brushing can dislodge them all. They eat their way into the very heart of the fiber, leaving it weakened, discolored, and dust stained.

Protection from mildew.—One of the commonest forms of cloth destruction is that called mildew. Mildew is caused by the penetration of large numbers of microscopic plants into the cloth fiber. When the work of these tiny forms of life has gone far enough, the color of the fabric changes and in time the cloth actually falls to pieces; nothing remains but the mildew plants themselves and their waste matter. Knowing these facts concerning the dangers of dust, we can see the value of the injunction to brush clothing after every using and to store it or hang it away only after it is perfectly dry. Moisture helps these little organisms materially.

Unused garments should be hung away carefully so that wrinkles may not form. Sleeves of valuable garments should be pressed out flat or filled with tissue paper. All spots should be removed as soon as possible for fresh spots or stains are always more easily eradicated than old ones. Light injures some colors, especially on fabrics that were never intended for daytime use. Such fabrics should be kept in dark, cool closets, or should be so wrapped as to keep out sharp light.

Storing textiles.—Storing goods is a science in itself. Providing the right temperature and the right amount of moisture, regulating the light—such things are matters which need to be carefully studied by anyone who has anything to do with textiles. Cloths and garments to be stored should, as a rule, be wrapped in blue, brown, or

other dark-colored paper, first, for the sake of protection from light which penetrates lighter papers more easily, and, second, because light papers—whites and yellows—tend to spot light-colored fabrics with yellow, as the bleaching process used in whitening paper is cheap and somewhat imperfect.

Goods to be packed should be perfectly dry, clean, brushed, and in order, that is, properly folded. All steel pins should be carefully removed or rust spots will form. Cloth should be rolled into bolts, ribbons into rolls, embroidery and laces should be wound on cards. This is, to be sure, the way in which these goods come to the retail store; but the point needs to be emphasized that in this same fashion these goods should be kept, even at home, and in small quantities. Consumers should carefully heed this caution.

Protection from insects.—All textiles are subject to attacks by insect or other living organisms, commonly called pests, the particular variety depending upon the given textile. As we have already seen, mildew attacks cotton and linen. Mildew is similar in nature to molds, several of which attack not only vegetable fibers but also wool and silk. Housewives of the past kept insects out of their linen chests by using aromatic oils or essences, such as cloves, tobacco leaves, camphor, cedar sprigs, wintergreen, and so on. This practice had some value but these aromatic substances simply acted as deterrents. They by no means prevented all depredations. There is only one certain preventive and that is to keep the textile goods where insects cannot get at them. Above all, textile goods should be frequently looked over, aired, and dusted, so as to prevent anything that does attack them from getting a very long start.

Prevention of destruction of textiles by moths.—Recently the Bureau of Entomology of the United States De-

partment of Agriculture concluded some practical investigations on the best methods of preventing the destruction of textile goods by moths and published a circular on the subject entitled, "The True Clothes Moths." The following description and recommendations as to remedies are taken therefrom:

"The destructive work of the larvæ of the small moths commonly known as clothes moths, and also as carpet moths, fur moths, etc., in woolen fabrics, fur and similar material during the warm months of summer in the North, and in the South at any season, is an altogether too common experience. The preference they so often show for woolen or fur garments gives these insects a much more general interest than is perhaps true of any other household pest.

"The little yellowish or buff-colored moths sometimes seen flitting about rooms, attracted to lamps at night, or dislodged from infested garments or portieres, are themselves harmless enough, and in fact their mouth-parts are rudimentary, and no food whatever is taken in the winged state. The destruction occasioned by these pests is, therefore, limited entirely to the feeding or larval stage. The killing of the moths by the aggrieved housekeeper, while usually based on the wrong inference that they are actually engaged in eating her woolens, is nevertheless a most valuable proceeding, because it checks in so much the multiplication of the species which is the sole duty of the adult insect.

"The clothes moths all belong to the group of minute Lepidoptera known as Tineina, the old Latin name for cloth worms of all sorts, and are characterized by very narrow wings fringed with long hairs. The common species of clothes moths have been associated with man from the earliest times and are thoroughly cosmopolitan. They are all probably of Old World origin, none of them being in-

digenous to the United States. That they were well known to the ancients is shown by Job's reference to a "garment that is moth eaten," and Pliny has given such an accurate description of one of them as to lead to the easy identification of the species. That they were early introduced into the United States is shown by Pehr Kalm, a Swedish scientist, who took a keen interest in house pests. He reported these tineids to be abundant in 1748 in Philadelphia, then a straggling village, and says that clothes, worsted gloves, and other woolen stuffs hung up all summer were often eaten through and through by the worms, and furs were so ruined that the hair would come off in handfuls.

"What first led to the association of these and other household pests with man is an interesting problem. In the case of the clothes moths, the larvæ of all of which can, in case of necessity, still subsist on almost any dry animal matter, their early association with man was probably in the role of scavengers, and in prehistoric times they probably fed on waste animal material about human habitations and on fur garments. The fondness they exhibit nowadays for tailor-made suits and other expensive products of the loom is simply an illustration of their ability to keep pace with man in his development in the matter of clothing from the skin garments of savagery to the artistic products of the modern tailor and dressmaker.

"Three common destructive species of clothes moths occur in this country. Much confusion, however, exists in all the early writings on these insects, all three species being inextricably mixed in the description and accounts of habits.

"The common injurious clothes moths are the case-making species (Tinea pellionella L.), the webbing species or Southern clothes moth (Tineola biselliella Hummel), and the gallery species or tapestry moth (Trichophaga tapetzella L.).

"A few other species, which normally infest animal prod-

ucts, may occasionally also injure woolens, but are not of sufficient importance to be here noted.

"The case-making clothes moth.—The case-making clothes moth (Tinea pellionella L.) is the only species which constructs for its protection a true transportable case. It was characterized by Linnæus, and carefully studied by Réaumur, early in the last century. Its more interesting habits have caused it to be often a subject of investigation, and its life history will serve to illustrate the habits of all the clothes moths.

"The moth expands about half an inch. Its head and forewings are grayish yellow, with indistinct fuscous spots on the middle of the wings. The hind wings are white or grayish and silky. It is the common species in the North, being widely distributed and very destructive. Its larvæ feed on woolens, carpets, etc., and are especially destructive to furs and feathers. In the North it has but one annual generation, the moths appearing from June to August, and, on the authority of Professor Fernald, even in rooms kept uniformly heated night and day, it never occurs in the larval state in winter. In the South, however, it appears from January to October, and has two or even more broods annually.

"The larva is a dull white caterpillar, with the head and the upper part of the next segment light brown, and is never seen free from its movable case or jacket, the construction of which is its first task. If it be necessary for it to change its position, the head and first segment are thrust out of the case, leaving the thoracic legs free, with which it crawls, dragging its case after it, to any suitable situation. With the growth of the larva it becomes necessary from time to time to enlarge the case both in length and circumference, and this is accomplished in a very interesting way. Without leaving its case the larva makes a slit halfway down one side and inserts a triangular gore

of new material. A similar insertion is made on the opposite side, and the larva reverses itself without leaving the case and makes corresponding slits and additions in the other half. The case is lengthened by successive additions to either end. Exteriorly the case appears to be a matted mass of small particles of wool; interiorly it is lined with soft, whitish silk. By transferring the larva from time to time to fabrics of different colors the case may be made to assume as varied a pattern as the experimenter desires, and will illustrate, in its coloring, the peculiar method of making the enlargements and additions described.

"On reaching full growth the larva attaches its case by silken threads to the garment or other material upon which it has been feeding, or sometimes carries it long distances. In one instance numbers of them were noticed to have scaled a fifteen-foot wall to attach their cases in an angle of the cornice of the ceiling. It undergoes its tranformations to the chrysalis within the larval case, and under normal conditions the moth emerges three weeks later, the chrysalis having previously worked partly out of the larval case to facilitate the escape of the moth. The latter has an irregular flight and can also run rapidly. It has a distinct aversion to light, and usually conceals itself promptly in garments or crevices whenever it is frightened from its resting place. The moths are comparatively short-lived, not long surviving the deposition of their eggs for a new generation of destructive larvæ. The eggs are minute, not easily visible to the naked eye, and are commonly placed directly on the material which is to furnish the larvæ with food. In some cases they may be deposited in the crevices of trunks or boxes, the newly hatched larvæ entering through these crevices.

"*The webbing, or southern clothes moth.*—The webbing, or southern clothes moth (Tineola biselliella, Hummel) is the more abundant and injurious species in the latitude of

Washington and southward. It occurs also farther north, though in somewhat less numbers than the preceding species. It presents two annual broods even in the northern states, the first appearing in June from eggs deposited in May, and the second in August and September. It is about the size of pellionella. The forewings are, however, uniformly pale ocherous, without markings or spots. Its larva feeds on a large variety of animal substances—woolens, hair, feathers, furs, and in England it has even been observed to feed on cobwebs in the corners of rooms, and in confinement has been successfully reared on this rather dainty food substance. The report that it feeds on dried plants in herbaria is rather open to question, as its other recorded food materials are all of animal origin.

"The larva of this moth constructs no case, but spins a silky, or more properly cobwebby, path wherever it goes. When full grown, it builds a cocoon of silk, intermixed with bits of wool, resembling somewhat the case of pellionella, but more irregular in outline. Within this it undergoes its transformation to the chrysalis, and the moth in emerging leaves its pupal shell projecting out of the cocoon as with the preceding species.

"*The tapestry moth.*—The tapestry moth (Trichophage tapetzella, L.) is rare in the United States. It is much larger than either of the other two species, measuring three-fourths inch in expansion of wings, and is more striking in coloration. The head is white, the basal third of the forewings black, with the exterior two-thirds of a creamy white, more or less obscured on the middle with gray; the hind wings are pale gray.

"This moth normally affects rather coarser and heavier cloths than the small species and is more apt to occur in carpets, horse blankets, and tapestries than in the finer and thinner woolen fabrics. It also affects felting, furs, and skins, and is a common source of damage to the woolen

upholstering of carriages, being rather more likely to occur in carriage houses and barns than in dwelling houses. Its larva enters directly into the material which it infests, constructing burrows or galleries, which it lines more or less completely with silk. Within these galleries it is protected and concealed during its larval life, and later undergoes its transformation without other protection than that afforded by the gallery. The damage is due as much or more to its burrowing than to the actual amount of the material consumed for food.

"REMEDIES.—There is no easy method of preventing the damage done by clothes moths, and to maintain the integrity of woolens or other materials which they are likely to attack demands constant vigilance, with frequent inspection and treatment. In general, they are likely to affect injuriously only articles which are put away and left undisturbed for some little time. Articles in daily or weekly use, and apartments frequently aired and swept, or used as living rooms, are not apt to be seriously affected. Carpets under these conditions are rarely attacked, except sometimes around the borders, where the insects are not so much disturbed by walking and sweeping. Agitation, such as beating, shaking, or brushing, and exposure to air and sunlight, are old remedies and still among the best at command. Various repellents, such as tobacco, camphor, naphthaline cones or balls, and cedar chips or sprigs, have a certain value if the garments are not already stocked with eggs or larvæ. The odors of these repellents are so disagreeable to the parent moths that they are not likely to come to deposit their eggs as long as the odor is strong. As the odor weakens the protection decreases, and if the eggs or larvæ are already present, these odors have no effect on their development; while if the moths are inclosed with the stored material to be protected by these repellents, so that they cannot escape, they will of necessity deposit their eggs, and the destructive

work of the larvæ will be little, if at all, restricted. After woolens have been given a vigorous and thorough treatment and aired and exposed to sunlight, however, it is of some advantage in packing them away to inclose with them any of the repellents mentioned. Cedar chests and wardrobes are of value in proportion to the freedom of the material from infestation when stored away, but, as the odor of the wood is largely lost with age, in the course of a few years the protection greatly decreases. Fur and such garments may also be stored in boxes or trunks which have been lined with heavy tar paper used in buildings. New papering should be given to such receptacles every year or two. Similarly, the tarred paper moth bags obtainable at dry-goods houses are of some value; always, however, the materials should first be subjected to the treatment outlined above.

"To protect carpets, clothes, and cloth-covered furniture, furs, etc., these should be thoroughly beaten, shaken, brushed, and exposed as long as practicable to the sunlight in early spring, either in April, May, or June, depending on the latitude. The brushing of garments is a very important consideration, to remove the eggs or young larvæ which might escape notice. Such materials can then be hung away in clothes closets which have been thoroughly cleaned, and, if necessary, sprayed with benzine about the cracks of the floor and the baseboards. If no other protection be given, the garments should be examined at least once a month during summer, brushed, and, if necessary, exposed to sunlight.

"It would be more convenient, however, so to inclose or wrap up such material as to prevent the access of the moths to it, after it has once been thoroughly treated and aired. This can be easily effected in the case of clothing and furs by wrapping tightly in stout paper or inclosing in well-made bags of cotton or linen cloth or strong paper. Doctor

Howard has adopted a plan which is inexpensive, and which he has found eminently satisfactory. For a small sum he secures a number of the large pasteboard boxes, such as tailors use, and in these packs away all winter clothing, gumming a strip of wrapping paper around the edge, so as to seal up the box completely and leave no cracks. These boxes with care will last many years. With thorough preliminary treatment it will not be necessary to use the tar-impregnated paper sacks sold as moth protectors, which may be objectionable on account of the odor.

"In the case of cloth-covered furniture and cloth-lined carriages, which are stored or left unused for considerable periods in summer, it will probably be necessary to spray them twice or three times, viz., in April, June, and August, with benzine or naphtha, to protect them from moths. These substances can be applied very readily with any small spraying device, and will not harm the material, but caution must be exercised on account of their inflammability. Another means of protecting such articles is to sponge them very carefully with a dilute solution of corrosive sublimate in alcohol, made just strong enough not to leave a white stain.

"The method of protection adopted by one of the leading furriers of Washington, who also has a large business and experience in storing costly furs, etc., is practically the course already outlined. Furs when received are first most thoroughly and vigorously beaten with small sticks, to dislodge all loosened hair and the larvæ or moths. They are then gone over carefully with a steel comb and packed away in large boxes lined with heavy tar roofing paper, or in closets similarly lined with this paper. An examination is made every two to four weeks, and, if necessary, at any time, any garment requiring it is rebeaten and combed. During many years of experience in this climate, which is

especially favorable to moth damage, this merchant has prevented any serious injury from moths.

"*Cold storage.*—The best method of protection, and the one now commonly adopted by dealers in carpets, furs, etc., is cold storage. The most economical degree of cold to be used as a protection from clothes moths and allied insects destructive to woolens and furs has been definitely determined by the careful experiments carried out at the instance of Dr. Howard by Dr. Albert M. Read, manager of a large storage warehouse company in Washington, D. C. These experiments demonstrated that a temperature maintained at 40 degrees Fahrenheit renders the larval or other stages of these insects dormant and is thoroughly effective. The larvæ, however, are able to stand a steady temperature as low as 18 degrees Fahrenheit without apparently experiencing any ill results. Dr. Read's experiments have extended over two years, and his later results as reported by Dr. Howard are very interesting. They have demonstrated that while a temperature kept uniformly at 18 degrees Fahrenheit will not destroy the larvæ of Tineola bisellinella or of the black carpet beetle (Attagenus piceus), an alternation of a low temperature with a comparatively high one invariably results in the death of the larvæ of these two insects. For example, if larvæ of either which have been kept at a temperature of 18 degrees Fahrenheit are removed to a temperature of 40 degrees to 50 degrees Fahrenheit, they will become slightly active and, when returned to the lower temperature and kept there for a little time, will not revive upon a retransfer to the warmer temperature.

"It is recommended, therefore, that storage companies submit goods to two or three changes of temperature as noted before placing them permanently in an apartment kept at a temperature of from 40 degrees to 42 degrees Fahrenheit. The maintenance of a temperature lower than

the last indicated is needless and a wasteful expense. Where the cost of cold storage is not an item to be seriously considered, the adoption of this method for protection of goods during the hot months is strongly recommended."

Care in laundering.—Care of textiles in laundering is highly important. Many a valuable fabric has been ruined by improper washing. Beautiful colors are sometimes spoiled, while soft, smooth, finely finished goods come out of the laundry rough, hard, and ugly in appearance. How goods shall be cleaned is a matter of great importance and one upon which the salesman needs to inform his customers so that they may get the greatest service out of their purchases.

There are four things to be considered before laundering or cleaning any textile fabric:

1. The kind of weave and the probable effect of washing and rubbing upon it.
2. The kinds of textile fibers used in the fabric.
3. The weight and strength of the fabric.
4. The degree of fastness of the colors.

Kind of weave.—The kind of weave is important to this extent, that if the weave is loose and sleazy, the fabric will not stand rubbing. Certain brocades and satins or sateens, for example, are not to be rubbed because the Jacquard figures would be damaged by so doing. The plain weaves show dirt the most easily, but likewise wash the most easily. Closely woven goods in twills do not soil easily, but hold dirt very tenaciously; such fabrics need most careful washing. Any weave that helps the cloth to absorb is in its nature more difficult to clean than an open weave fabric.

Kind of fiber.—The kind of textile fibers used in the fabric should be determined in advance, for each textile fiber demands methods of laundering different from the

others. For example, cotton can stand more rubbing and more soaping than any of the other fabrics in proportion to its weight and strength. But cotton is quite susceptible to damage when brought in contact with acids. The chief difficulties in laundering cotton goods are in retaining brightness of dye or printing and in ironing with irons of proper temperature. Cotton can stand a great deal of what would be abuse to other textiles.

Linen is similar to cotton in most respects. Bleached linens show tendencies to yellow with time; they then require special treatment such as exposing to sunlight and laying out on the snow or grass.

Wool, on the other hand, presents a number of entirely different problems. Wool is in danger of shrinking, hardening, and scorching, as well as of losing its colors. Washing in too hot or too cold water, the use of alkalies or strong soaps, or rubbing and running through tight wringer rolls shrinks and hardens wool fabrics. Alkali may even destroy wool fiber. For these reasons wool needs special care in laundering.

Silk, like wool, an animal fiber, requires no less careful handling in laundering.

Weight and strength of fabric.—The weight and strength of the fabrics to be cleaned should be considered in order to determine what laundering processes the fabric will stand.

Colors of fabrics.—Finally, the fastness of the colors should be considered. Dyes that are fast under one method of washing may fade under another. Hence in preparing to launder an article, a colored woolen fabric, for example, precautions should be taken to prevent injury either to the wool or to the coloring matters.

Mixed goods.—Mixed or union goods present a special problem that is sometimes difficult to solve. The usual method is to launder the material as if it were entirely

composed of the weakest kind of fiber in its composition. Wool and cotton should be laundered as if it were all wool. Cotton and silk should be laundered like silk.

Cleaning wool.—Wool fabrics or garments should be washed in soft water. Before placing the fabrics in the water, the water should be heated to a temperature of 85 degrees to 100 Fahrenheit, little more than lukewarm. Into the water should be placed enough soap of good quality, as free as possible from any uncombined alkali, to make suds. The addition of a little ammonia will help take the dirt out of the fabrics. Next, the garments, blankets, or fabrics, should be brushed and shaken to remove any loose lint, dust, or other particles. They are then to be placed in the water and allowed to soak for an hour, after which they should be kneaded and drawn backwards and forwards, up and down in the suds. They should never be rubbed or wrung. Soap should not be rubbed directly upon the fabric. Soap and rubbing cause the wool to felt; the better the grade of wool, the greater and more rapid the felting. The wool fabrics may now be removed to another tub of water of the same temperature but with less soap and ammonia; here they are stirred about in the same careful manner, rinsed, and removed for a final rinsing to a third tub with pure water of the same lukewarm temperature. After the last rinsing, the water is pressed out gently and the fabrics are dried. Sunshine and the open air are the best driers, though out of the question in a laundry. The drying temperature should never be more than 100 degrees Fahrenheit. Napped goods should be freshened after drying by rubbing with a piece of flannel. Soft woolens, delaines, cashmeres, and serges should be soaked for only a short time. If the fabrics need stretching, this should be done just before drying. Most woolens do not need ironing. Those fabrics that must be ironed should be covered with damp muslin and pressed with a heavy iron

just warm, not hot. A hot iron will shrink flannel and turn it yellow. Cashmere should be dampened before ironing.

Laundering silks.—Silks need about the same treatment as that given to wool, although silks do not mat or felt as do wools under conditions of heat, alkali, and rubbing. The water to be used in washing silks should be soft, of an even warm, not hot temperature, and only a neutral soap free from alkali should be used. Silks should not be rubbed but simply drawn backwards and forwards and poked up and down in the water. Nor should silks be crushed, squeezed, or wrung out with a wringer unless placed between folds of linen cloth. Silk goods should be ironed slightly damp, except pongee, which should be ironed dry. The face of a silk fabric should not be touched with a hot iron. The proper method is to protect the silk fabric by covering it with linen when ironing.

Cleaning colored goods.—Colored goods of any kind need special precautions that depend upon the nature of the dyes in the cloth. A complete set of directions for laundering colored goods would take up more space than can be given here. It will be sufficient for present purposes to enumerate the conditions that are especially likely to cause fading.

1. Long soaking in water.
2. Boiling or overheating.
3. Cold water or freezing.
4. Alkalies—washing sodas, washing fluids, washing powders, and poor soaps.
5. Washing two different colors in the same tub at the same time. There may be an affinity between these that may cause either or both to run.
6. Exposing to direct sunlight.
7. Ironing with too hot irons.

Setting the colors.—Colors may sometimes be set so that they will not come out in washing under ordinary circumstances. This desirable object is accomplished by using salt, alum, borax, vinegar, or ox gall in the wash water. The occasions for such agents vary greatly, and no general direction can or should be given. What will set some colors is likely to cause others to fade.

Methods of cleansing fabrics.—The purpose of laundering is both to remove dirt and impurities and to whiten or brighten the cloth. In the ordinary washing this is done both by mechanical and chemical means. The rubbing, boiling, rinsing, and so on, are mechanical means; ammonia, borax, washing powder, and several other substances commonly applied to loosen dirt or dissolve it, are chemical means. Coarse, heavy fabrics that can stand it may have both mechanical and chemical methods applied, but the finer the goods, the more careful the decision must be as to which method is advisable. In general, it may be said that, whenever possible, chemical help should be used, provided it is of such nature as not to injure the fabric; for chemical cleansing saves labor, while mechanical means all require labor or power.

Bluing.—Bluing, commonly a preparation made of Prussian blue, is used in laundering to whiten clothes. Most textiles are somewhat yellowish in tone, and if the bleaching and washing have been imperfectly done, the yellow is very decided. Bluing mixes with the yellow, and the result is a whiter appearing fabric. The use of too much bluing is damaging to both cotton and linen fabrics; it causes stains which are removed with difficulty.

Starching.—Laundered goods are frequently starched. The purpose of starch is the same here as in the manufacture and finishing of textiles. It increases the weight, stiffness, and body of the fabric. But starch serves another important purpose. Starched fabrics are not soiled so

easily as soft fabrics, and they wash out very easily. Starch in fabrics makes it easier to remove stains, the starch being an absorbent and therefore drawing much of the stain to itself. Simply washing the starch out removes much of the stain. Starch neutralizes some staining substances such as tannin from tea and coffee. Where the starch is heavy, however, it makes the fabric brittle and breaks it to pieces prematurely.

Yellow discoloration.—Yellow discoloration in fabrics fresh from the laundry is practically inexcusable. It is caused by definitely known practices that can readily be obviated by study, care, and by purchasing necessary equipment. The causes which most commonly produce this yellow discoloration are:

1. The use of hard water. All laundering should be done in soft water. Where soft water is not available, hard water can usualy be made soft by chemical means that will not injure fabrics.
2. The use of too much carbonate of soda or washing soda. Washing soda has little or no cleansing effect in itself. It is an active chemical that seeks to combine with some other substance. In laundering, its chief use is to soften hard water. It can easily be used in too large quantities, making the clothes yellow rather than white.
3. Insufficient rinsing.
4. The use of too little water in the wash tubs. Better results are always obtained by using more water than is necessary rather than less.
5. Washing too hurriedly, and using strong soaps and ammonia to hasten the process.
6. Too quick drying in overheated air.

Theory of removing stains.—The removal of stains is a subject that may properly be considered here. Here, as in

laundering, the character of the textile must be most carefully considered. But not only that; the character of the stain should also be known if it is to be removed without damaging the goods. The aim in stain removal is, of course, to find some substance that will attack, draw out, or loosen the staining material, yet leave the goods unharmed. Various substances may thus be used. Some stains can best be removed by covering them with an absorbent material that will draw out the staining substances. Others can be eradicated best by covering them or moistening them with some liquid that will dissolve them but will not attack the dyes or injure the cloth fiber. Sometimes the stain should be treated with a chemical that will combine with the staining material and form a new substance that can be washed out with water. Finally, where all other methods fail, the stain may be removed by bleaching. The removal of stain may, therefore, be accomplished usually by some one of the following methods:

1. Absorbents.
2. Solvents.
3. Acids or alkalies, or other chemicals.
4. Bleaching agents.

Absorbents.—The common absorbents that may be used for stain removal purposes include blotting paper, common brown paper, powdered chalk, whiting, pipe clay, fuller's earth, magnesia, gypsum, starch, melted tallow, corn meal, bran, and so on. Absorbents can be used to best advantage on fresh stains still moist. Hot grease, fresh ink stains, coffee or tea stains can be treated in this way, not to remove them entirely but rather to remove a large part of the staining substance and prevent it from spreading further. Absorbents are especially valuable for use preliminary to treatment by some other method.

Solvents.—Solvents actually attack and dissolve the

staining substance so that it may be flooded out by the dissolving liquid. Some of the common solvents are water, hot or cold, alcohol, gasoline, benzine, kerosene, turpentine, and chloroform. The removal of ordinary soil by means of washing in water is the most frequent example of this method. Cold water will remove milk and cream stains, stains from sugar, candies, and cocoa. Hot water may be used to remove fresh coffee stains. The mineral oils, benzine, gasoline, and kerosene, are useful solvents of grease, oil, wax, and paint. Gasoline is probably the best for use with woolen and silk fabrics but not with cotton. Gasoline, however, is very volatile, and passes off rapidly in the form of inflammable gas. It should, therefore, be used out of doors in the daylight; and never in a room where there is a fire or a gas flame or kerosene light, otherwise disaster is likely to occur. Vaseline, itself a mineral grease from the same source as kerosene or gasoline, may be softened and loosened by soaking the stained fabric in one of these mineral oils. When sufficiently liquid, the whole may in turn be dissolved in ammonia and water or washing soda and water, whereupon the mineral oil combines with the alkali in the form of an emulsion which can be washed out. Alcohol is a solvent for grass stains, for varnish and paint, and for several other substances. Its great value is enhanced by the fact that it will not harm delicate fabrics. Frequently, too, it is an excellent solvent for medicine stains. Turpentine is the universal solvent for paint, varnish, resins, oils, rubber, and the like. It is also a chemical solvent for iodine, sulphur, and phosphorus. Chloroform is the best of the solvents, and likewise the most expensive. It acts powerfully on grease, wax, camphor, rubber, iodine, and many other sorts of stains. No other solvent is so satisfactory for use on delicately colored textiles. When colors seem faded, chloroform is the best known substance for reviving them. Grease, itself the most frequent stain-

ing agent, must be used in some instances as a solvent for other substances. Tar and pitch may be removed by the use of lard, as may grass stains too if they are fresh. After obliterating the original stain, the grease is removed by some regular grease solvent, such as benzine, hot water and soap, or gasoline.

Chemical Action.—Stains made by acids, such as fruit juices, wine, or lemon juice, or even by stronger acids, are best eradicated by means of some solvent; unhappily it is not always possible to find at hand a solvent other than water, and this is not effective after the acids have dried. In the failure of solvents, the best plan is to apply an alkali which combines chemically with the acid, forming thus a new substance which ordinarily will be easily dissolved by water. Ammonia is one of the best alkalies for this purpose, not being likely to injure even delicate fabrics.

"For the removal of stains and spots from colored goods and carpets, ammonia takes first place. It is one of the first chemicals to be used. It can be applied to cottons, wools, and silks, and leaves no trace of its use. Grease flies before its application, and when diluted with water, spots caused by orange or lemon juice or vinegar are removed by it from the most delicate materials. From carpets, curtains, and suits of clothing, it will remove almost every stain."—*The Modern Laundry,* Vol. II., page 82.

Washing soda (carbonate of soda) and cooking soda (bicarbonate of soda) are also valuable alkalies for use on uncolored cottons and linens. Furthermore, acid stains may be dissolved and removed by the use of certain weak acids, such as oxalic, citric, and tartaric acids, sour milk, and very weak muriatic acid. The theory seems to be the same as for the using of kerosene on vaseline. The acid liquids combine with the staining material and dissolve it, making it easy to wash out with water.

Acids.—Acids must be used carefully because of their

destructive effects on cotton and linen and on many dye substances. The acids named above, except sour milk and muriatic acid, are all vegetable acids and quite weak. Oxalic acid is made from the sorrel plant. Citric acid is made from lemons or other citrus fruits; tartaric acid, from grape juice. Each of these is valuable in removing fruit stains, iron rust, and old-fashioned, iron-gall, ink stains. When salt is added to any of them, a bleaching process sets in. Tartaric acid is a highly useful and safe acid for stain removal; no textile is injured by it. Since it is, however, a weak acid, its action is neither rapid nor strong enough to remove certain very deep stains.

Bleaching.—If no other means succeeds a stain must be removed by bleaching. There are several bleaching methods and substances, differing greatly in effectiveness. Practically none of them can be used on colored goods without endangering the colors in the fabric. Some are destructive to the fabrics themselves and must be used with care and judgment. A few of the most common may be named here.

Oxygen.—Sunlight and air together form a gentle but effective bleaching agent provided that haste is not imperative. All discolored white goods may be improved by exposure to sunlight. Sulphur fumes are used most frequently for wool and silk goods. The method of application is very simple. The spot to be bleached is dampened in water and then held over burning sulphur so that the fumes penetrate the spot directly. After the stain has whitened, the fabric needs washing in soapsuds, and rinsing in clean water.

Bleaching powder.—Bleaching powder or chloride of lime is the most frequently used bleach for cotton and linen goods. It is valuable in removing refractory stains such as ink spots, mildew, old blood stains, and iron rust. The spot is covered with chloride of lime and moistened with

some acid such as vinegar, oxalic acid, tartaric acid, or sour milk. The bleaching is rapid and should be stopped by rinsing thoroughly in water just as soon as the stain disappears. A bleach weaker than chloride of lime but working on the same principle is known as Javelle water.

Javelle water is made as follows for household use:

1 pound sal soda or pearl ash,
¼ pound chloride of lime,
2 quarts cold water.

After this mixture is allowed to stand for several hours, the clear liquor is poured off for use. It must be kept in a dark, cool place if it is to retain its strength. Javelle water may be used for the same purposes as bleaching powder, and, being less active, it does not require such cautious handling. Many housekeepers use Javelle water for practically all sorts of colored stains. This doubtless saves time, but is hardly economical, for Javelle water does destroy textile fiber.

Peroxide of hydrogen.—Peroxide of hydrogen is an excellent bleach, and should be used much more frequently than at present, for it seems to have no destructive effect on textile fiber. Its only disadvantage as compared with Javelle water is its higher cost.

Borax may at times be used as a mild bleaching agent in laundering clothes that show yellowish tints or streaks.

Lemon juice and salt make a bleach that works much like chloride of lime, though it is not quite so strong. Any acid added to salt starts chemical bleaching.

Principles of Removing Stains.—In concluding our study of the principle of removing stains, we may enumerate certain points of practice:

1. The sooner the stain is attended to, the better. Fresh stains are always easier to remove than old ones.

2. Use stain removers in the following order until something is found that is strong enough to remove the stain: absorbents, solvents, chemical combinations, bleaching agents. Never use a stronger means of removing a stain than is necessary.
3. Determine first, if possible, what caused the stain and work directly upon that information.
4. Do not rub a chemical into a stain. Dab it in, using a cloth, sponge, or the fingers.
5. Use pure chemicals in removing stains. Impure ones are likely to leave other stains fully as difficult to remove as the original stain.
6. Strong chemicals, such as acids, should be applied drop by drop to the stained fabric moistened with water or steam. The use of a medicine dropper for this purpose is most convenient. Using this, one can readily watch the progress of the remedy and control it.
7. To keep stains from spreading under the influence of solvents, it is best first to apply the solvent in a ring around the stain and then gradually to work in towards the center of the stain.

STAINS AND HOW THEY MAY BE ERADICATED.—The following list of stains arranged in alphabetical order gives the more ordinary ones together with the best means for treating each. Some stains are quite indelible, such as certain ink stains and brown stains from scorching. In such cases, the only remedy is to cover the spot by dyeing; even then the stain may show through the dye.

Acid.—To stop the corrosive action of acids spilled on fabric, the fabric should be dipped at once, if possible, into ammonia. If the stain becomes dry, ammonia will not be strong enough. Tie up a little washing soda or cooking soda in the stained part, make a lather of soap and cold

soft water, immerse the fabric, and boil until the spot disappears. This treatment frequently causes colored goods to fade, but moistening with chloroform will often restore the original color. If chloroform fails a solution of nitrate of silver will often be of service. If this does not succeed there is no hope of recovering the fabric without redyeing. When yellow stains on brown or black woolen or worsted goods are caused by very strong acids, such as nitric acid, they should be padded repeatedly with a woolen pad soaked in a concentrated solution of permanganate of potash.

Aniline and aniline inks.—Wet the stained spot in acetic acid, and then apply diluted chloride of lime, and wash out carefully.

Apple and pear.—Soak in paraffin for a few hours and then wash. The paraffin, when melted, is a strong absorbent for such fruit colors.

Blood.—If fresh, soak for twelve hours in cold water; then wash in tepid water. If the mark still remains, cover it with a paste of cold water and starch, and expose to the sun for a day or two. Old stains require bleaching with Javelle water, or an application of iodide of potassium diluted with four times its weight of cold water.

Brass.—Brass stains on fabrics may be removed by dabbing with rancid lard or rancid butter.

Burns.—These are caused perhaps by overheated irons. If bad, they are hopeless, and must be hidden by dyeing. Slight burns yield to treatment with soap and water.

Changed colors.—Stains are often caused by local fading of dye. They can, in most cases, be removed by reviving the dye. The manner of doing this depends upon the kind of dye. If the nature of the dye is unknown, dilute ammonia should be tried, or dilute acid, or chloroform. It does not matter which is tried first, but the effect must be carefully watched, and the first chemical washed out at once when it is clear that it wil! not be successful. The

solutions of acid or ammonia should be very dilute, at least at first.

Coffee.—Pour boiling soft water through the stain, and while it is still wet hold in the fumes of burning sulphur. Washing with soap and water is, however, usually sufficient without using the sulphur. Glycerin also removes coffee stains; it should be diluted by the addition of four times as much water and a little ammonia.

Chocolate and cocoa.—Cocoa stains can be removed by using cold water. Otherwise the treatment should be the same as for coffee stains.

Fruit.—Fruit stains can be treated like coffee stains if fresh; if old, rub on both sides with yellow soap, cover thickly with cold water, starch, and bleach by exposing to the sun and air for three or four days. Fruit stains are acid stains and may also be removed by treating with alkalies. One method is to apply ammonia and alcohol mixed in equal proportions.

Grass.—Dab with spirits of wine or alcohol. Application of tartaric acid or cream of tartar is sometimes effective if used in boiling water, the stained fabric being dipped in several times. A grass stain may sometimes be removed by rubbing lard over the spot and then washing. Grass stains differ greatly in ease of removal. Sometimes ammonia will take out such stains, especially if it is found that an acid treatment has no effect. Intractable spots need bleaching.

Grease.—Grease stains if still fresh should be treated at first with absorbents such as fuller's earth, chalk, talcum powder, or flour. Ironing small grease spots over brown paper is sometimes helpful. The use of absorbents should be supplemented by some solvent such as benzine, gasoline, turpentine, or chloroform. To keep the grease from spreading, the solvent should first be applied in a ring around the outside of the spot, after which the spot may

be covered. In using the grease solvents any proximity to fire must be carefully avoided.

Ink.—The great difficulty in removing ink stains is due to the fact that ink is made from so many different chemical substances. The best way to treat an ink stain is to apply some solvent that will not harm the fabric no matter what sort of chemical caused the stain. Fresh ink stains may frequently be washed or rubbed out in milk. If the stains do not begin to fade at once, the fabric should be allowed to stand in the milk for at least twelve hours. In the meantime, the milk beginning to sour, the weak acid will make itself felt on the stain. If this does not remove the stain, it should next be treated as for aniline ink. Most of the directions given in household guides for treating ink stains are valueless because they apply to inks that are now no longer made and used. If the methods suggested above do not succeed, then the stain should be covered with melted tallow for a few hours. This should be removed by washing in hot soapsuds. If this fails, then the spot should be bleached out with Javelle water.

Iodine.—Soak the stain in ammonia. Rub with dry bicarbonate of soda (cooking soda) until stain comes out.

Iron rust.—Apply citric acid, oxalic acid, or tartaric acid. If this acid treatment does not remove the spot, bleach it by covering it with lemon juice and salt and exposing it to sunlight.

Medicine.—Medicine stains may usually be dissolved and removed by means of alcohol.

Mildew.—Treat as for iron stains. Boiling in strong borax water is recommended. Mildew is usually very refractory. The bad color can be removed by bleaching if the remedies proposed above do not seem sufficient, but it is more than likely that the fabric will be very tender after the bleaching process.

Milk and Cream.—Milk stains can be removed with cold

water or with cold water and soap. Hot water sets the milk stain and makes it difficult to remove.

Mud.—Dip in gasoline or benzine. Small spots may be concealed by using chalk or white watercolor when it is not convenient to have the cloth cleaned with a solvent at once.

Paint.—Dab with turpentine. A mixture of turpentine and chloroform is often very effective in removing old paint stains from even delicate fabrics. Naphtha soap should be used in washing out paint oil stains.

Perspiration.—Use strong soap solutions and expose to sunshine. Perspiration under the arm is of a different chemical composition from that of other parts of the body, and is neutralized by dilute hydrochloric acid. The acid should be very dilute, about one part acid to seventy-five or a hundred parts water.

Tar.—Cover with lard, let stand a while, and then wash in hot soapsuds.

Tea.—Treat as for coffee stains. Tea contains tannic acid, and may therefore be treated by using ammonia or some other alkali.

Varnish.—Treat like paint stains.

Vaseline.—Vaseline is not soluble in acids or alkalies, but can be dissolved in kerosene or benzine, and then washed out with hot soapsuds.

Wine.—Treat like fruit stains. Fresh wine can be very largely neutralized by spreading salt over the spot while wet.

CHAPTER XXIV

TEXTILE TESTS

Reasons for textile tests.—Each of the commonly used textile materials has its peculiar characteristics. Each varies from the others in length, strength, diameter, elasticity, crimpiness, luster, and color—elementary qualities which determine a special result in the fabric made from the particular fiber. Hence fabrics made from the different textiles differ in strength, elasticity, luster, color, and feeling, even when manufactured by precisely similar qualities. Each textile must be carefully selected with a view to its particular purpose. Everyone, therefore, who has anything to do with the selecting or with the purchasing and sale of textiles needs to know thoroughly these fundamental qualities of the different textiles.

But not only are there these original differences in the various textiles; there are even greater differences in the qualities of fabrics due to the processes of weaving and finishing. Men continually devise new and more complicated methods of constructing and finishing the goods. The quality of the cotton fiber used may be generally the same, yet very great differences may be found in even such staple goods as cotton sheetings. "All wool and a yard wide" may mean much or little as to textile quality, according to the methods of manufacture. Silk cloths have differences as great as there are between summer and winter. Pure linen may be of great value; it may, too, be trash. The one, therefore, who handles textiles needs to know not

only the elementary qualities of the textile fibers, but also enough about the processes of manufacture to determine the qualities that may be expected from each.

Finally, the one who handles textile goods needs a special knowledge of the subject in order to determine whether he gets what he pays for. The great differences in value among the textiles and their products have led to a great deal of imitation, especially by way of so manipulating the cheaper textiles as to make them look like the more expensive goods, or again by mixing higher priced with cheaper textiles, sometimes with the purpose of procuring certain very desirable qualities, at other times to produce goods with only the appearance of the higher priced textile at a cost more nearly that of the cheaper. Unscrupulous manufacturers and dealers have often been able to sell these imitations and adulterated goods at prices far above their intrinsic value simply because their customers did not know how to estimate values properly.

The buyer of textiles, therefore, needs to know textiles and textile tests in order to know positively what he is getting. A cheap textile is just as legitimate as a high priced one provided the purchaser knows what it is and pays only its value. The value of a textile lies in the service that it will perform, whether that be for wear, for appearance, or for style. Waste occurs whenever more is paid for a textile than it is worth as compared with other textiles in the market. Waste occurs again whenever a textile is put to a use for which it has no desirable qualities and for which it was never intended. Buying textiles for the service they will render demands that the purchaser should know textile values and the means or tests of determining those values.

Those who sell textile goods need this knowledge in even higher degree than consumers since they are usually called upon to handle a greater variety of textiles than any one

consumer. As retailers come to see clearly that their function is to supply what will satisfy, instead of merely to dispose of their stock at a profitable figure, they will increasingly recognize the need for special textile knowledge on the part of salespeople and others who serve customers. A salesman's word upon his goods should be authoritative; his service should consist in supplying each customer with what will give the most satisfaction for the money.

Necessity for simple tests.—Knowledge of textiles and textile tests are then all-important for the store buyer, the salesman, and the consumer. For practical purposes the tests need to be both reliable and simple. The methods of the laboratory will hardly do for the average store or home. There is neither time nor equipment for elaborate chemical or microscopical examinations. The tests must require little time, labor, expense, or equipment. The results must be made as evident as possible. Something, therefore, must doubtless be sacrificed in the way of accuracy, but this may be atoned for by the common sense and experience of the one making the test. An experienced eye and hand will go far in helping to determine textile qualities, especially when checked by a few simple chemical or other scientific tests.

THE KINDS OF TESTS TO BE MADE

The following are the classes of necessary textile tests that may be applied readily in any retail store or home, and with very slight expense of time or money:

1. To determine the quantity, the length and width, the thickness and weight.
2. To determine the strength, firmness, flexibility, and durability.
3. To determine fastness of color and permanency of finish.

4. To determine the kind of material used in the construction of the fabric.
5. To determine the presence and quality of any adulterations used in the fabrics.

Length and width.—It is to be presumed that all who buy textiles will give the needed attention to the facts of measurement. The matter of length is simple, but probably not enough attention has been given to width properly to recognize qualities of the various widths into which fabrics are made up. Those who make up men's and women's clothing have in some cases made careful investigations of the possibilities of cutting up the various widths of suitings. According to some large manufacturers of ladies' garments, cloth made in fifty-four-inch widths cuts up to the best advantage; that is, leaves the least waste, with the present styles. Not enough study has yet been given to this point to assure an authoritative statement covering the general textile uses. It is clear, however, that the width of a cloth is a matter to be considered by all who have to cut it up.

A consideration of width in relation to price is another important matter. This calls for no more knowledge than an application of simple arithmetic. For example, which is the more economical to buy (assuming that both widths cut up with about equal amounts of waste), twenty-seven-inch cloth at sixty cents or thirty-six-inch cloth at seventy-five cents a yard? The twenty-seven-inch cloth will cost (60c.÷27/36 or ¾) eighty cents a square yard, or five cents more a yard than the thirty-six-inch cloth, which costs seventy-five cents a square yard.

Which will cost the more, eighteen-inch fabric at $1.30 a yard, or twenty-seven-inch fabric at $2.10 a yard? Reducing both to denominations of square yards, we find the first costing ($1.30÷18/36 or ½) $2.60 a square yard, and the second costing ($2.10÷27/36 or ¾) $2.80 a square

yard. The narrower fabric is, therefore, twenty cents cheaper for each square yard than the wider. These two illustrations will probably suffice to show what care the buyer of textiles must exercise.

Weight.—The weight of the fabric, especially when free from adulterations or weighting materials, is a fair guide to the value of the fabric, other things being equal. Woolen goods, blankets, suitings, and dress goods should be weighed on scales, and should be sold by weight, after the construction, style, and quality of the textiles have been determined. The mere sense of touch is not accurate enough. Large consumers of such goods almost invariably have the goods weighed, and base their purchases upon standard weights for each yard of goods. Other goods such as silks, cottons, and linens could also be weighed with profit were it not for the prevalence of weighting substances in such fabrics. Simply weighing a piece of silk gives no idea as to the amount of pure silk in its construction. It would show the amount of silk if it were pure, but cannot reveal possible adulterations. Other tests have to be employed for such goods.

Durability, a relative term.—A universal requirement of all textile fabrics is a certain amount of durability, or ability to withstand wear. This quality may vary greatly according to the use to which the goods are to be put. Millinery trimming fabrics are not used so roughly as dress goods; hence, they need not be so strong as dress goods. Considering their purposes, they may be equally durable, since they may both last equally long in use. Cloth intended for men's wear is usually made stronger than that for women's wear, for the obvious reason that in use men's goods are often subjected to greater wear and strain than are women's goods.

Durability is often sacrificed to secure certain fashionable or artistic effects, thus causing some higher priced

goods to be less strong than cheaper goods. The higher qualities represented by higher prices to the yard are by no means always qualities of greater durability. But, in any case, whoever has anything to do with textiles is likely to desire a certain degree of strength and durability as a matter of course. As stated before, buying or selling cloth is essentially nothing more nor less than buying or selling the service that cloth performs. This service may be either a fashionable or pleasing appearance in use, or a durability in wear. Sometimes these two factors work together, sometimes they are in opposition. In some cases it may be impossible to preserve a reasonable amount of durability while producing a fabric entirely desirable in appearance. It has been most difficult to do this in many of the women's dress goods where extreme sheerness, filminess, or laciness was considered essential to good looks. In some other cases, fashion swings to the other extreme, calling for appearance and strength far beyond the actual needs of the garment; wherefore many clothes go out of fashion long before they wear out. Good value, so far as durability is concerned, is laid away in chests, hung up in closets or clothes presses, or sold to second-hand dealers and ragmen, to be reduced to shoddy, paper pulp, or what not. With fashion and its effects we are not here concerned. We shall simply give our attention to some of the causes or conditions of durability and the methods or tests applicable to determine durability and strength.

Quality of fiber.—It is clear that the strength of the fabric depends upon a great number of things. Primarily the quality of the fiber used in making the yarns must be considered. No matter what the textile may be, short, damaged, weakened fibers do not make as strong yarns, and therefore not as strong fabrics, as long, healthy, fresh fibers. Something of the quality and of the fiber may be learned by simply unraveling a few yarns drawn from the

fabric and examining each little fiber carefully and testing its strength by pulling it to pieces. With experience in this, a person may become a very good judge of the fiber quality.

Quality of yarns.—Cloths made from two-ply or three-ply yarns, that is, yarns which have been made by twisting two or more simple yarns together, are, as a rule, more durable than single yarns. Cloths made from combed yarns, such as worsteds, are stronger and more durable, pound for pound, than cloths made from carded yarns, such as woolens. The combing principle is applied to cottons as well as wools; hence, this point needs consideration in dealing with cotton goods, especially in hosiery and knit goods, in which lines combed cottons are mostly used now.

The difference between carded and combed yarns may be determined by simply untwisting the yarn and noting the arrangment of the fibers in the yarn. Worsted yarns are made from fibers that have been combed and the fibers therefore all lie parallel. Woolens are made from carded wool yarns. In this class the fiber runs in every possible direction and with absolutely no order of arrangement.

The same arrangement of fibers in yarns is also to be noted in cottons. The highest grade silks are made from thrown silk yarn threads, which in turn are made from several strands of cocoon silk, all lying parallel. All but the poorest waste silks are combed and prepared much the same as worsted yarn, and hence show the parallel arrangement, but differ from thrown silk in the fact that the fibers are short. The poorest grades of silk are carded and spun much like carded wool. The arrangement can be traced easily in any of these cases by simply untwisting a strand and noting how the fibers lie.

Nature of weave.—To determine the character of weave requires some knowledge of the general classes of weaves. The cloth to be tested is simply carefully examined to see how the threads are interlaced. As an aid to this process

it is best, whenever possible, to unravel a few threads in both directions of the cloth. A magnifying glass can be used to good advantage, especially a little glass known as a "linen tester." These magnifying glasses are made in sizes permitting one to study the cloth surface in spaces from a quarter inch square up to an inch square. They cost little and very materially aid the eye. Every textile goods salesman should own one.

The "counts."—The number of threads or yarns running each way—that is, the number of "counts"—may be determined by marking off an inch square on the cloth and actually counting the threads running each way within the square. Using a pin or other sharp-pointed instrument in separating the fibers one by one assists considerably in the counting. A "linen tester" magnifier can be of great assistance in determining the count since the space magnified is either a quarter, half, or full inch, so that no time need be lost in marking off an inch on the cloth with a ruler or tape. If a few yarns are unraveled under the glass, their sizes can be noted, and also how hard they are twisted and whether they are single or two-ply; with care, too, the length of fibers used in making the yarns can be determined.

The higher the number of "counts" per square inch, the yarn remaining the same in size and quality, the more durable the cloth. Cotton sheetings may run from thirty-five to seventy counts to the inch in either direction, and other cloths vary in the same manner. The counts are not usually the same for both ways in the cloth.

As illustrations rather than as standards, the following figures are given showing the counts as found in certain samples of cloth:

Long cloth	70 x 64
Nainsook	83 x 76
Lawn	77 x 76

Persian lawn	79 x 82
Fine shirting	93 x 88
Percale	66 x 58
Madras shirtings	68 x 48
Calico	61 x 46
Fine gingham	86 x 84
Organdy	67 x 64
Marquisette	51 x 34
Piqué	135 x 83
Table damask	66 x 57
Curtain scrim	24 x 24
Poplin	103 x 46

Closeness of weave.—Holding the cloth up to the light and looking through it will be of assistance in determining whether the weave is close or loose, whether any filling or weighting materials such as starch have been added, and whether the yarns are uniform or not.

Firmness.—Another test, used to determine the firmness of the weave, is to scrape the thumbnail diagonally across the weave. If the construction is loose, there will be a pathway of loosened threads made across the cloth after the thumbnail. This test can be applied very well to cottons, linens, and silks.

Elasticity.—The elasticity of the fabric, a quality much desired for certain uses and one which usually adds to durability, may be determined by crumpling a small portion of the cloth in the hand and then noting its behavior when the pressure is removed. If it springs back into its former shape quickly, its degree of elasticity is very high. This is a characteristic that may best be seen in good grades of all wool fabrics. But the test may also be applied to other textiles in the same manner.

Weighting.—Rubbing between the fingers white goods that are suspected of being weighted with starches, China

clay, or other heavy materials, will often reveal the weighting substances in the form of dust. When tearing causes a dust to fly, this may be taken as a sign of heavy weighting.

Strength.—The easiest method of determining the relative strength of fabrics is by comparing the amounts of strength necessary to pull them apart with the hands. Care should be exercised to make the conditions of the tests as nearly equal as possible. About the same width of cloth should be grouped in the thumbs and fingers preparatory to the pull in each case and the pull should be exerted in the same direction for each fabric, either in the direction of the warp threads or of the weft or filling. In fact, the best way to test the strength of a fabric is by comparing the pull necessary to tear the fabric both in the direction of the warp and of the filling. In some cases it may be found that a cloth is much weaker in one of these directions than the other. The cloth should be judged by its weakest points rather than its strongest, for in use it will wear out or go to pieces at its weakest point first. Samuel S. Dale, editor of the *Textile World Record* and one of America's greatest textile experts, says that the proper way to apply this test is to grasp the cloth in both hands about an inch apart and then to pull steadily, rather than to draw the cloth tight in the hands and then to place the thumbs together and press them into the cloth. "By the former method there is a direct strain on the hands, enabling the resistance offered by the cloth to be fairly judged. By the second method there is a powerful leverage by means of the contact of the two thumbs, producing a high tension of the fabric with comparatively slight effort."

Quality of Tests.—It should be remembered that such tests as those given above are only relative, and the results must be considered only as approximations. For example, to determine the breaking strength of a fabric by pulling

it to pieces in the hands is far from an accurate test. Our judgment as to the amount of pull that we exert is bound to vary according to our physical condition. What may seem like a comparatively easy pull at one time may seem like a hard pull at another. Large users of textiles, institutions which cannot afford to make any mistakes on such points as these, measure the breaking strength by taking strips of equal widths and testing them in machines that register every pound and ounce required to pull the cloth apart. Such instruments are called dynamometers and work on the same principle as a spring balance. Firms using them usually have certain standards which all cloth must reach before being considered acceptable.

Tests for flocks.—Finally, there remain, especially applicable to woolen and worsted goods, tests which determine whether flock or pulverized wool enters into the construction of the fabric, whether the cloth will turn shiny easily, whether the nap will wear well, and whether the cloth will keep its shape.

Flocks or very short wool fibers obtained from shearing the surface of wool or worsted cloths are often worked into woolen cloths in the fulling process. They are nearly always applied to the back of the cloth, sometimes to both sides. When the fulling is well done, these short fibers have penetrated the body of the cloth deeply and do not come out easily. But when imperfectly fulled, or when too much of this kind of material is used, it comes out easily in wearing. Its presence may be determined by brushing the back of the cloth briskly with a good stiff brush. If flocks have been used, a number of short fibers will come out in the brushing.

Tests to determine whether wool will turn shiny.—Many otherwise excellent wool fabrics are objectionable because they easily turn shiny. One can tell to a certain extent in advance whether this objectionable quality will develop or

not. The sheen or shiny surface on a worn wool fabric is due to the fact that the loose fibers, fuzz, or nap is pressed down or worn off completely, exposing only the surfaces of fibers lying lengthwise in the yarns of which the fabric is composed. From this it will be clear that worsteds are more likely to wear shiny than woolens. Cloths made from the long, lustrous, straight fibers are far more liable to turn shiny than shorter, softer, and more crinkly wools, there being fewer ends exposed. Fulling or felting tends to prevent this objectionable feature; but fulling also changes the character of such a material as serge. If the loose fibers are simply pressed down they may be raised, removing the shine by steaming, rubbing with a similar material and then pressing carefully. Dark-colored or hard-woven fabrics seem to become shiny more easily than light-colored or soft-woven varieties.

Estimate of durability of nap.—The durability of the nap on such wool goods as kerseys may be estimated by first determining which way the nap lies. This may be done by rubbing the hand over the cloth in various directions. It will be found that in one direction the cloth feels smooth while in the opposite direction the ends of the fibers strike the hand noticeably. Moving the hand in the direction that offers the least resistance is called "with the nap." The opposite direction is said to be "against the nap." By wetting the end of the thumb and rubbing it against the nap, the character of the nap can readily be ascertained. A poor construction that will wear out easily is readily displaced and becomes frowsy looking after but little handling. However, if the nap consists of short, thickly set fibers that offer considerable resistance to rubbing with the wet thumb, the cloth will stand hard wear without the nap becoming rough or loose. A long, loose, wavy nap is never very durable. Heavily napped goods, whether intended for dresses, overcoats, blankets, or what

not, should not be expected to wear as well as lighter napped fabrics.

Tests to determine whether cloth will hold its shape or not.—Whether or not a cloth will hold its shape is due entirely to the body of the fabric. Firmly woven goods hold up much better than soft or loosely woven goods. Coupled with firmness should go a high degree of elasticity. Draping qualities may be tested easily by noting how the fabric acts when thrown into loose folds or in a jumbled heap. Draping qualities are dependent primarily upon flexibility.

Fastness of color, a relative term.—Absolute fastness of color is not a possibility in textile manufacture. All that can be done is to produce colorings which will be fast under the ordinary conditions of use; that is, fast in some degree to light, air, washing, soap, rubbing, street wear, perspiration, and so on. In addition to these qualities, manufacturers are often under the necessity of providing for still other features which do not concern us here, such, for example, as fastness to alkalies, acids, heat, and finishing processes, since the cloth must pass through such conditions before reaching the finished stage.

To produce colors that are very fast requires considerably more time, material, and expense than to produce colors not so fast. This is a general rule. Where a less fast color will serve the purpose fully as well in use, it seems unwise to assume the additional cost of producing a very fast color. Military cloths, for example, which are intended for much exposure to sun, air, and rain, need to be dyed with much more attention to fastness than fine silks in delicate shades for evening wear, that is, for use under artificial light. The latter colors might be very fleeting in bright sunlight, but since the fabric is not intended for wear under such conditions, its service is not reduced by using the weaker colors. Fabrics of weak material or loose weave do not need and do not receive the fast colors re-

quired by strong, durable fabrics. Curtains and carpets should both be dyed fast to light, but carpets should also be dyed fast to friction and the wear of feet, while curtains should be dyed fast to washing in hot water and soapsuds. Hence, the same coloring substances may by no means serve for both classes of fabrics. Underwear and stockings should be dyed fast to washing, soap, perspiration, and wear. Linings must be dyed fast to friction and perspiration. In the same manner every sort of textile should be dyed with special reference to its use if the best results are to be obtained at the lowest costs. Students applying the following tests should bear these facts in mind.

Fastness to light.—To determine how fast a colored fabric may be to light and air, the samples to be tested should be cut in two and the halves carefully marked for subsequent matching. One-half of each sample should then be laid away under cover from light, while the other half should be hung out in a sunny place for several days. As to standards of fastness, it may be noted that the very strongest, fastest dyes, such as Turkey red, begin to fade between the twenty-fifth and thirtieth days in summer, while indigo blue fades between the twelfth and fifteenth day. Summer light is more powerful than winter light; hence, allowances have to be made for the season of the year. A color that remains fast a month may be termed "fast." If it fades in about two weeks, it may be called "moderately fast." If it fades in less than fourteen days, it is called "fleeting." Allowances are also to be made for the effects of moisture, particularly salt water, in the air. Such moisture makes some colors more fast, while rendering others less so.

Fastness to washing.—Fastness to washing may be determined by actually washing a sample of the fabric thoroughly in hot soapsuds and then comparing it with the same goods still unwashed. In laboratories the usual

method is to make up strong hot soapsuds, using pure soap and distilled water, and to boil the colored sample of cloth or yarn in these suds for twenty minutes along with a piece of undyed cloth of the same kind. If the colors are not absolutely fast, they will "run" from the dyed fabric into the undyed and give to this piece of goods a tint. Sometimes the experiment is performed several times over on the same sample to note just how many washings are required to show any perceptible fading or running.

Fastness to friction.—Fastness to friction or rubbing is usually determined by rubbing the colored goods briskly over a clean, white, laundered cotton handkerchief. If the handkerchief is discolored in any way, it shows that the fabric is not fast to friction, and therefore not suitable for hosiery, underwear, lining material, and so on.

Fastness to street wear.—Fastness to street wear includes fastness to light, rain, dust, and friction. Light, washing, and friction tests have already been described. To determine if a fabric is proof against spotting as a result of drops of water or of dust, a sample may be sprinkled with water, preferably water in which a little lime has been added, and then dried before brushing off. Any change in color or luster is carefully noted, since this would indicate unfitness for street wear or other outdoor use.

Fastness to perspiration is best tested by wearing a sample of the fabric next to the skin for a few days. Military cloths are tested for fastness against perspiration by placing small samples in the shoes of the marching soldiers, or by placing them on a horse's back under the saddle. Several days' test in these ways shows conclusively the degree of fastness.

Permanency of finish.—Permanency of finish is determined by the same tests as those used to determine fastness of dyes. The sun, washing, and friction tests especially reveal any weakness in finish. Weighting materials

used for cottons usually come out in the wash test, as do the special calender surface finishes.

Tests for kinds of textiles.—Tests for determining the kinds of material used in a piece of fabric consist mainly in recognizing by sight and feeling the easily observed characteristics of the several textiles. Difficulties arise in great numbers, however, when these textiles are combined. To tell linen from cotton, silk from mercerized yarn, natural wool from shoddy, and mulberry silk from artificial silk usually takes more careful analysis than any eye or hand unaided by other tests can yield. Here chemical or microscopic methods are necessary. Some of these tests can be made easily; the mere fact that they are chemical, for example, should in no wise discourage the untechnical salesman or consumer. The process of testing a fabric solely to determine what kinds of fibers it comprises is known in chemistry, and generally in the textile industries, as qualitative analysis.

When the presence of certain textiles has been determined in a fabric, it may often be desirable to investigate yet further in order to determine what proportions of each enter into the total make-up of the fabric. This process is called quantitative analysis. This is much more difficult outside of a laboratory, but one can frequently ascertain approximately the amounts of each substance or fiber used in the fabric.

Difficulties to be encountered.—As already indicated, each of the common textile fibers has a peculiar appearance which anyone can learn to recognize quite easily with experience. This was the chief means of telling wool from cotton and linen from cotton fifty years ago. But in the intervening period there has been tremendous progress in the textile production, much of which has taken the form of so changing the cheaper kinds of textile fibers in appearance that they closely resemble the more costly fibers.

In fact, it is now difficult for even the most experienced to tell by the sense of sight and touch alone the differences between a particular fabric and its imitation.

Use of the microscope.—Under a high-power microscope the essential characteristics of each kind of fiber are, of course, more easily made out than with the naked eye; imitations may likewise be easily made out, for the original characteristics are in no case entirely changed in the processes which textile manufacturers employ in producing the imitations. But a high-power microscope is expensive, and requires some skill in manipulation as well as time for making the proper tests. Hence, its use cannot be described here. Textile students desiring to go into a study of the use of the microscope can find a number of excellent manuals which give in detail instructions in its use and its applications to textile fibers. Despite its cost and the care required in using it, the day is probably not far distant when every well-equipped dry goods house will have as a part of its equipment a textile laboratory, and in this connection the microscope will be a most useful and valuable instrument.

Detection of adulterations of wool.—Wool is commonly adulterated or cheapened by the addition of either cotton or shoddy (refuse wool goods reduced to fiber by shredding machines), sometimes of both. It helps somewhat to know how these cheapening substances are introduced into pure, natural wool. Knowing this, one is prepared to look for evidences of the mixing in definite places.

Cotton is often carded or combed into the wool before the spinning. The yarn then becomes a uniform mixture of cotton and wool in the proportions in which they were mixed. The cotton, when worked into the wool in this way, is often difficult to detect by the common tests.

Sometimes cotton threads are twisted in with worsted in the process of drawing before the spinning.

Again, cotton threads of the same color as the wool or worsted threads are introduced in the weaving, either as filling or warp. In some cases, the entire warp is made of cotton yarn and the entire filling is made of wool, or vice versa.

Cotton yarn is sometimes veneered with wool fibers by means of special machines which produce a yarn that outwardly resembles all wool.

Shoddy is mixed with natural wool in about the same manner as cotton, and even cotton and shoddy mixtures are sometimes made, using cotton yarn for warp and shoddy for filling.

Cotton may be distinguished from wool and discovered in the wool mixtures by the following means:

Appearance.—Cotton fibers can usually be told from wool fibers by the eye, especially if assisted by a magnifying glass. Cotton fibers are straight and dull in luster, while wool is curly or crinkly and possesses considerable luster or lively appearance. However, some varieties of cotton, like the Peruvian, closely resemble wool fiber of poorer grades; hence, the need for more accurate tests than mere use of the eye.

Fire test.—Cotton is a vegetable fiber, and wool is an animal fiber. Vegetable fibers are all composed mainly of cellulose, an easily burned substance, whereas all animal fibers are composed mainly of nitrogenous materials, which burn with difficulty. Vegetable yarn can be told from animal fiber by setting fire to a strand of each. The vegetable fiber will burn quickly, while the animal fiber will burn very slowly and with difficulty. At the same time the burning animal fiber gives off a disagreeable odor that is characteristic of burning hair, feathers, horn, and so on. The odor that comes from burning wool is especially disagreeable because of the fact that besides the nitrogenous materials it also contains sulphur, which gives an additional

strength to the odor. The burning test is a certain means of determining whether a fiber is vegetable or animal. If the test shows that a fiber is vegetable, other methods must be employed to determine what particular vegetable. It is not likely that linen fibers would be mixed with wool; hence, any vegetable fibers detected in woolen yarn or cloth would almost certainly be cotton. Since cotton and wool are frequently spun together in the same thread, the burning cannot be used as an absolute test except for individual fibers.

Boiling-out test.—Burning is a chemical test, though a simple one. There is another chemical test that anyone can apply to determine whether or not wool yarn or cloth contains any cotton or other vegetable fiber, a test that is more valuable than the burning test, since it permits the making of an estimate of the quantity of any cotton introduced. This is known as the "boiling-out test." A solution is first prepared by dissolving one ounce of caustic potash or caustic soda in a pint of water. The water should be heated to make the caustic dissolve more quickly. This amount may serve for several tests. Boiling a small sample of pure wool in some of this solution entirely dissolves the sample in less than fifteen minutes, but the same amount of boiling would have practically no effect on cotton or linen—another difference in effect due to the fact that vegetable fibers are cellulose, while animal fibers like wool contain nitrogen. Therefore, if a mixture of cotton and wool were to be boiled in the solution for fifteen minutes, all of the wool would be destroyed, while the cotton would remain.

Before this boiling-out test, the sample should be carefully washed, dried, and then weighed. After the test, the residue should once more be weighed; whereupon, by simple arithmetical calculation, we learn the approximate proportions of cotton and of wool in the fabric, thus:

$$\left\{\begin{matrix}\text{weight before placing}\\ \text{in caustic solution}\end{matrix}\right\} - \left\{\begin{matrix}\text{weight of}\\ \text{residue}\end{matrix}\right\} = \left\{\begin{matrix}\text{weight of material}\\ \text{dissolved}\end{matrix}\right\}$$

that is to say,

$$\text{cotton and wool} - \text{cotton} = \text{pure wool.}$$

As stated in the case of the burning test, the only distinction made by the test is between the vegetable and animal fibers. Because of our knowledge of the costs of textiles, we feel certain that linen would not be used instead of cotton as the vegetable fiber, and the wool is recognized by its own qualities from any other animal fiber such as mohair or silk, although both of these would, like wool, dissolve in the caustic.

Acid test.—By using a strong solution of sulphuric acid (80 per cent) instead of caustic, and by immersing the cotton-mixed wool in this chemical for about twelve hours, and then washing the residue in alcohol, it will be found that the cotton is dissolved instead of the wool, and comparisons can be made by weight in this experiment as well as in the former case.

Detection of shoddy.—Shoddy cannot be distinguished from natural wool by any chemical test, since shoddy is itself wool. It differs from natural wool only in that it has been used before for textile purposes and is in most cases less strong and less elastic than natural wool. It is very difficult to distinguish shoddy from natural wool, but there are certain characteristics which indicate the presence of shoddy, such as very short fibers, fibers of various colors, lack of uniformity in size and general character of the scale structure, ends broken and uneven, scales missing on parts of the fiber. Three characteristics of shoddy that are revealed by the compound microscope cannot be seen by the naked eye:

1. Because of the wear to which most shoddy has already been subjected in some fabric and because of the

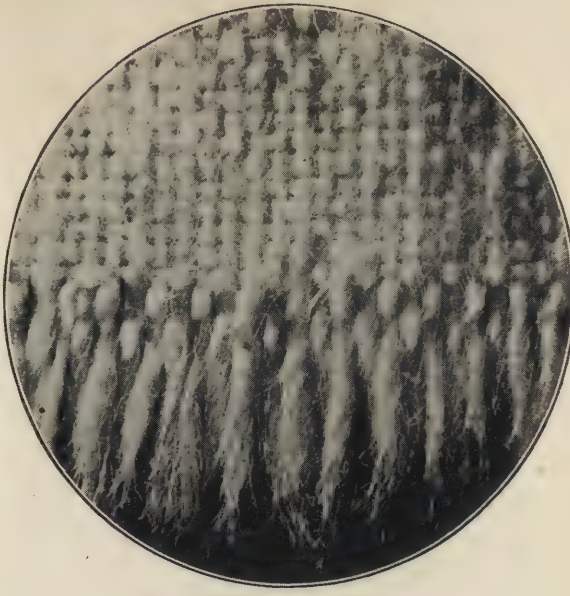
shredding process which tore the individual fibers apart from the old fabric or yarn, the original scales found on all sheep's wool may be largely missing or broken down on shoddy fibers.

2. For the same reasons, the ends of shoddy fibers may not be so regular as those of natural wool clipped from the sheep's back. Shoddy, under the microscope, presents ends that are broken and torn.

3. Wherever the shoddy came from dyed fabrics it retains some of the coloring matters from the former dye even under the new dye. This makes a difference in the hues visible under the microscope, even in very dark-dyed materials. When this variation in color is to be found, one is usually justified in concluding that shoddy is present.

For the student who has not access to a microscope, there is no adequate test for shoddy. But since the chief evil of shoddy is its lessened durability, the student may fall back upon the more general textile tests for strength and durability given earlier in this book. What is most important is that the fabric purchased shall give adequate service for the money expended. It is even possible that the presence of good grades of shoddy would be preferable to the poorest grades of wool in the fabrics purchased; it all depends upon the uses to which the fabrics are to be put and the prices paid for them.

Tests for Distinguishing Cotton and Linen.—Owing to the great difference in cost between cotton and linen, it is only natural that cotton should often be used in place of linen. It is natural, too, that cotton and linen should be mixed for many purposes, and even that cotton should be substituted for linen in deceptive ways. It is not so easy to distinguish cotton from linen as it is to distinguish vegetable fibers from animal fibers. Both cotton and linen are composed almost entirely of the same substance, cellulose. Yet there are generally differences enough, physical



TORN END OF COTTON MATERIAL.

TORN END OF LINEN MATERIAL.

and chemical, to allow accurate distinction between the two.

Tearing test.—In general, linen is stronger than cotton. It takes more force to tear linen cloths than to tear cotton goods of equal thickness and sizes of yarns; further, the sound of tearing linen is more shrill than that of tearing cotton. The torn edge of linen cloth shows fibers that are decidedly unequal in length, parallel, and glossy. The torn edge of cotton cloth shows short, curly, rather even, lusterless fibers projecting. Snapping a linen thread apart leaves the fibers remaining straight and outstretched, whereas breaking a cotton thread quickly causes the latter to curl up.

Weight and feeling.—Linen is nearly a fifth heavier than cotton, bulk for bulk. It has a leathery feeling that is absent in cotton. On the other hand, cotton feels warmer and holds the heat better than linen. It is estimated that cotton is from fifteen per cent to thirty per cent warmer than linen.

Appearance.—In construction, carded cotton yarn is much like carded wool yarn, while linen yarn is like worsted yarn. The glossy linen fibers lie more or less parallel throughout the thread or yarn.

Light test.—On holding linen cloth against light, the threads and the fibers composing the threads appear uneven and streaked. It is not possible to make linen yarn as uniform as cotton yarn; hence, this test may be used as a check on other tests where it is desired to determine the presence of linen threads.

Burning test.—Burning the end of a linen thread leaves the fibers in the same relative position as before with no change except the scorched appearance. Burning a cotton thread causes the fibers to spread out like a tuft.

Oil test.—Linen cloth freed from dressing by washing and boiling absorbs oil much better than cotton does. When, therefore, a cotton-mixed piece of linen goods is

dipped in oil, the linen fibers look transparent if held against the light, while the cotton remains more nearly opaque.

Acid test.—Linen stands the action of sulphuric acid better than cotton, and a test can be made based upon this difference. The samples are first carefully washed to remove all dressing, dipped in concentrated sulphuric acid for a minute or two, and then washed in water and dried on blotting or filter paper. All that remains on the blotting paper is linen. The cotton almost immediately dissolves in the acid. By weighing the sample before and after the test, an approximation of the amount of cotton can be obtained as follows:

$$\left\{\begin{array}{c}\text{weight of fabric dipped}\\ \text{in sulphuric acid}\end{array}\right\} - \left\{\begin{array}{c}\text{weight of}\\ \text{residue}\end{array}\right\} = \left\{\begin{array}{c}\text{weight of part}\\ \text{dissolved}\end{array}\right\}$$

That is to say,

$$\text{linen and cotton} - \text{linen} = \text{cotton}.$$

Tests for silk and its imitations and adulterations.—Silk, the most valuable of all textiles, has more imitations than any other fiber. More processes have been invented to preserve the appearance of genuineness while utilizing cheaper fibers, than in any other textile industry. Silk fabrics are cheapened in at least seven ways:

1. Spun silk is introduced in place of thrown silk.
2. Wild silks, such as tussah, are used in place of mulberry silk.
3. The silk fiber is weighted with tannin and mineral salts.
4. Artificial silk has been produced which in appearance rivals true silk.
5. Cotton and linen are given finishes to resemble silk. Mercerizing is an example.
6. Silk is mixed with wool for fancy effects.

7. Silk is mixed with cotton or other vegetable fibers likewise for fancy effects, or for giving body to what might otherwise be a very flimsy silk fabric.

Detection of Spun Silk.—Spun silk is often very difficult to distinguish from thrown silk. Of course, the fibers are much shorter, but it is very difficult, if not impossible, to tease out the tiny separate silk fibers from silk yarn. Under the microscope the presence of spun silk can be determined by two facts. First, the fibers of waste silk are usually irregular in form; second, the sericin, or gum, is irregular in waste or spun silk. These facts are accounted for by the fact that the waste silk comes from the parts of the cocoons that do not reel off readily.

Detection of Wild Silk.—When it is desired to determine whether wild silk, such as tussah, yamanai, or senegal, enters into the structure of a silk fabric, one of the best tests is to prepare a solution of chromic acid as follows:

Dissolve chromic acid in cold water until the water will dissolve no more. Add an equal volume of pure water. The result is a semi-saturated or fifty per cent solution of chromic acid. Place the suspected silk sample in this solution and bring it to a boil. True silk, that is, mulberry silk, will dissolve within a minute after boiling begins, while tussah and other wild varieties will remain insoluble for at least three minutes.

Detection of Weighting.—Weighting of silk can usually be detected by the burning test. Separate threads from the warp and the weft are set on fire with a burning match. Pure silk burns very badly and stops burning as soon as the burning match has been removed. Practically no ash is formed (less than one per cent), and the end of the fiber left unburned takes the shape of a little bulb. Weighted fibers, when burned, leave a considerable amount of ash, and the entire thread may keep its shape after being

burned. When only the filling or the warp is weighted, applying the flame to a sample of the cloth seems to consume only one set of threads, the unweighted ones, the others keeping their form because of the heavy ash content. To determine just what weighting substances are used is a subject for a more technical treatise than this.

Tests for Artificial Silks.—Artificial silks made from cellulose, cotton, wood pulp, or other vegetable substances can be distinguished from true silk by the fire test. All cellulose silks burn readily and give off no odor; true silk burns badly and gives off the odor of burnt feathers. Artificial silks, as a rule, are not so strong as true silk and not so elastic. When wet, artificial silks now on the market swell and become weak, whereas no such effect takes place in true silk. In a caustic potash solution, artificial silk turns yellow, while true silk remains colorless.

Another chemical test is frequently used to distinguish true silk from the artificial. Dissolve ten parts copper sulphate in one hundred parts water and add five parts glycerine. A white precipitate will form. Add enough caustic potash solution to dissolve this precipitate. To perform the test, immerse the suspected sample in this solution at ordinary room temperature. True silk will dissolve almost at once. Artificial silk will not dissolve.

Detection of cotton.—To distinguish between silk and cotton or other vegetable fiber, apply the same test that was used to distinguish between wool and cotton, namely, boiling for fifteen minutes in a caustic potash solution. The silk dissolves, but the vegetable fiber is in no way affected.

Another method is to prepare a solution of fuchsine, a dyestuff, and then decolorize it by adding caustic potash or caustic soda solution drop by drop until the color disappears. A sample of cloth made up of silk and cotton is immersed in this liquid for half an hour, and then washed

carefully. When taken out, the silk, if there is any in the cloth, is red, while the cotton remains colorless.

Detection of mercerized cotton.—Mercerized cotton may be determined as follows: A solution is prepared by dissolving five ounces of potassium iodide in about a pint of water. To this solution add one or two ounces of iodine, and mix with another solution made by dissolving thirty ounces of zinc chloride in twelve ounces of water. The cloth sample should first be soaked in water, immersed in this prepared solution for three minutes, and then rinsed in water. Mercerized cotton will have a deep blue color, while unmercerized cotton will wash out white. The blue of this solution on mercerized cotton will show through quite heavy dyes.

To distinguish mercerized cotton from silk in the same fabric, use the same tests as for ordinary cotton and silk mixtures.

SEPARATION OF SILK AND WOOL.—Silk and wool mixtures may be tested by immersing the fabric sample in a solution of zinc chloride of 1.7 specific gravity. Any druggist can make up this preparation. In this solution silk dissolves, but wool is unaffected.

Another chemical method of separating wool and silk is by boiling the fabric sample in strong hydrochloric acid for fifteen minutes. In that time the silk will have dissolved, while the wool will remain intact.

Use of the magnifying glass.—Silk that is mixed with cotton or wool can often be studied most easily by means of a magnifying glass or linen tester such as has already been described. The true silk fibers can usually be distinguished by sight and the proportion of true silk to adulterant or other component in the mixture fairly approximated.